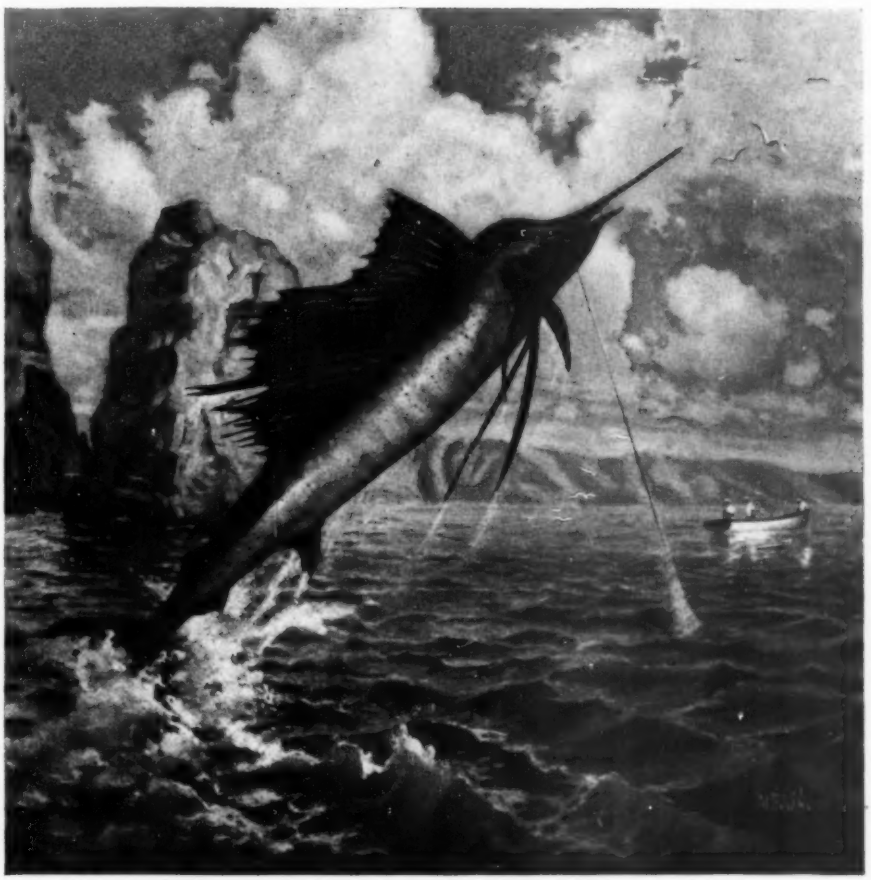
NATURAL HISTORY

JAN.-FEB.
1928

FISH
NUMBER



JOURNAL OF THE AMERICAN
MUSEUM OF NATURAL HISTORY

NEW YORK, N. Y.

FIFTY CENTS

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NATURAL HISTORY

VOLUME XXVIII CONTENTS FOR JANUARY-FEBRUARY NUMBER 1

Published bimonthly, by the American Museum of Natural History, New York, N. Y. Subscription price $3.00 a year.

Subscriptions should be addressed to James H. Perkins, Treasurer, American Museum of Natural History, 77th St. and Central Park West, New York City.

NATURAL HISTORY *is sent to all members of the American Museum as one of the privileges of membership.*

Entered as second-class matter April 3, 1919, at the Post Office at New York, New York, under the Act of August 24, 1912.

Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized on July 15, 1918.

THE SEA ROVERS

Fig. 1.—A school of sharks, led by a twelve-foot tiger shark, are attacking a sea turtle. On the left is a large hammer-headed shark and in the background a huge man-eater. Sketched from the group in the American Museum by F. L. Jaques

NATURAL HISTORY

VOLUME XXVIII, No. I
JANUARY–FEBRUARY

FISH NUMBER

E. W. GUDGER
EDITOR

A Tour of the New Hall of Fishes

BY WILLIAM K. GREGORY

Curator of Ichthyology, American Museum

THE FISH HALL of the American Museum is now in process of preparation. Within a few months it will be thrown open to the public, and at that time the visitor will be able to see for himself the exhibits described by Doctor Gregory in the following "guide" to the Hall.—THE EDITORS.

SWAYING and darting in a sunlit mountain brook, a live trout is resplendent in rainbow colors and streamline form. The same trout stuffed and mounted is often a stiff and grimy souvenir of death. And when we have to fill a whole museum hall with dead fishes and plaster casts of dead fishes, can any Ezekiel of the taxidermists' guild bring such dry bones to life? Such might well be the thoughts of the seasoned museum visitor as he approaches our portals. But, once he is lured inside our hall by the gleaming legend FISHES OF THE WORLD, our cue is to give him no further time for doubts or for odious comparisons of our exhibits with those of the institution in Battery Park. We plan, figuratively speaking, to open our performance with a "crash," and hope to keep our visitor fascinated with the wonders of the fish world on the trip around the hall. But, lest he sink into apathy from overstimulation, we plan also to revive him at intervals with quiet scenes and large spaces of ocean blue and green.

William Beebe maintains, from a wealth of personal experience and investigation, that the reputation of sharks for ferocity is largely overrated. The late Carl Akeley affirmed the same of the gorilla, and even primitive man, both ancient and modern, has his champions. But, while honoring these humane and generous sentiments, we submit that, at least in the case of the tiger shark, the circumstantial evidence suggests that this pirate of the seas does not always wait, like the hyæna, for someone else to do his killing. At any rate, we felt warranted, after considerable inquiry, in pushing forward the installation of our large shark group at the south end of the hall. This is an underwater view entitled "The Sea Rovers," into which the department of preparation, under the able direction of Mr. James L. Clark, is putting some brilliant scenic effects. In the lower right quarter of the scene a large sea turtle is flapping his way in desperate haste and looking as distressed and apprehensive as a sea turtle well can. Swooping down upon him from the upper left hand corner is a converging pack of sea hounds, led by a large tiger shark, all hot on the scent. In the distance we see somewhat dimly a huge form that dwarfs the sharks of the foreground. It is the dreaded white shark or man-eater, and we can readily foresee that a few seconds later, when the water is a bloody maelstrom of lashing bodies, the giant will move up grandly, shoulder the lesser hounds away, and engulf the prize himself. In this group Mr. Clark and Mr. Jaques have achieved a masterpiece of great strength and simplicity.

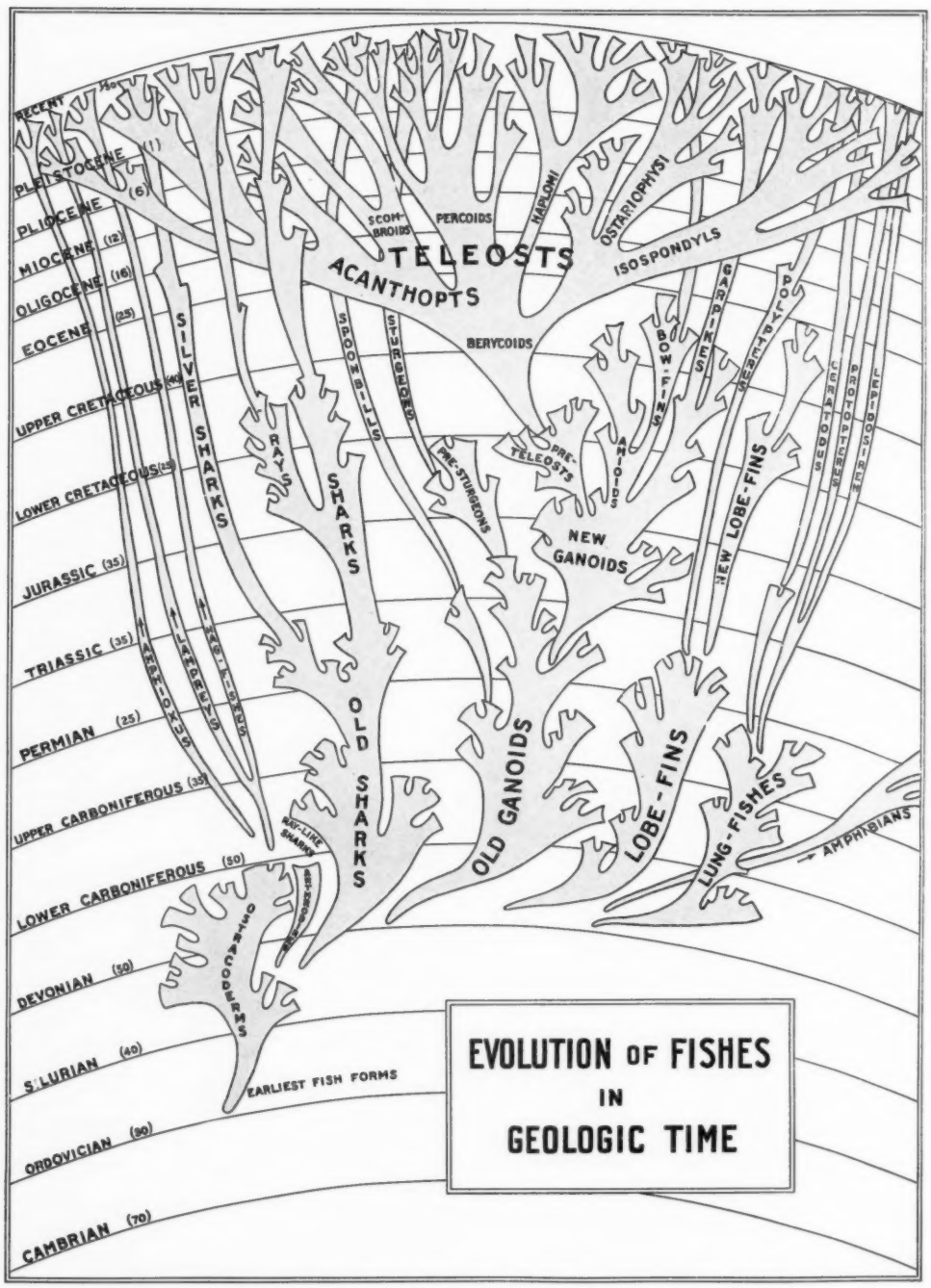


Fig. 2.—A "family tree" showing the genealogical history of the fishes

With the idea of sharks as living creatures thus awakened in his mind, the visitor may now perhaps be intrigued into looking on either side of the entrance at the two great wall cases which are full of lifelike models

and mounted specimens of sharks, big and little, ordinary and extraordinary. These sharks are not packed together in severely straight columns, like definitions in a dictionary, but are clustered in schools, as if swimming, upon a mottled bluish-green field that brings out all their streamline forms and low-visibility colors. In one wall case the central figure is the hammer-headed shark, a graceful form whose horizontally flattened head serves as a bow rudder and enables him to make surprisingly quick dives and turns in his pursuit of the swift bluefish. The center piece of the other large shark case is the stout-bodied thresher, which uses its amazingly long tail to round up the schools of small fish upon which it feeds.

If our visitor is now in the receptive mood for scientific knowledge, he may stop and look at the large decorative panel by Miss Isabel Cooper, entitled Evolution of Fishes in Geologic Time. Here the successive ages of the earth's history, as known to the geologists, form a background of zones arranged in ascending series, and upon these zones is depicted the "family tree" or genealogical history of fishes, so far as it has been inferred from a study of fossil fishes of past ages and from the evidence afforded by the comparative anatomy and development of existing forms. Gazing at this panel, the visitor may well be surprised at the literally inconceivable antiquity of the major subdivisions of the class or superclass of fishes, since as far back as the lower Devonian age (several hundred million years ago according to conservative recent estimates) the grand division that later gave rise to our modern sharks and rays was already well separated from other grand divisions, including the "Old Ganoids," the "Lobe-finned Ganoids," and the "Lung-fishes." He will also notice another main stem, coming out from between the lobe-finned ganoids and the lung-fishes and labelled "To Amphibians." This branch stands for those ardent though fishy beings who first dared to take their air straight, and to inhale its fiery essence directly into their lungs, without diluting it with frequent gulps of foul water. Adventurous pioneers they were, wriggling up from the mud flats, putting the fan-shaped paddles their ancestors had evolved to the new use of pushing the body along on terra firma, thereby making such good speed that they could capture the giant cockroaches and fat larvæ of huge dragon flies. They thus laid the foundations for the long line of tetrapodal pirates that culminated in *Homo sapiens*.

Absorbed in such pleasing reveries, our intelligent visitor will then look toward the center of the chart to that incomparably distinguished and aristocratic division designated "Old Ganoids," the F. F. V.'s of the ancient world. These were the victorious mail-clad knights of old Devonian days who supplied the *vis a tergo*, the pressure from the rear, that drove our own ancestors out of the water. Even before that time the Old Ganoids, like true pioneers of a strenuous race, had nearly exterminated the aboriginal inhabitants, the lowly Ostracoderms—grovelling creatures—which were Nature's first attempts to evolve a fish.

Spreading into and subduing all the inland waters, the Old Ganoids, like the Mongol invaders of Europe, gradually deployed into many hordes or divisions. The histories of these divisions, in so far as it has been unravelled by the patient researches of ichthyologists, afford many instructive parallels

with the histories of human dynasties and cultures. The members of each main division, branching off from the central stock at a given time and place, inherit from it a particular grade of organization and a special "culture" or way of life. What then shall they do with this inheritance, when they are set off by themselves, a new colony in some far-off place, where they are safe from the competition of their own kind, but have still to meet the competition of the present inhabitants and the unexpectedly severe climatic aberrations of a new environment? Fish and men respond to this situation in much the same way. Some races rapidly adapt themselves to the new conditions. Finding some favorable line of advance, they recklessly sacrifice their old equipment and old ways, force themselves into the new economic niche, and eventually become so highly specialized in its ways that they are fit for nothing else, or at best can meet new changes in the environment only by further specializations in the same general direction. In other words, starting in as conservatives, they skip the progressive stage and soon develop into radicals and freaks. Again and again many of the descendants of the Old Ganoids left the straight and narrow path of their ancestors, gave up the free life of buccaneers in the open waters, and slunk away to become mud-grubbers, like the sturgeons and carps and catfishes, or to take refuge in holes and crannies and become slinking ratlike pilferers, living like eels in foul waters. Not so the old guard, the saving remnant of the Old Ganoids. Yielding as slowly as possible to an insidious pacificism, they asked and gave no quarter, and age after age somehow managed to give rise not only to new hordes of more or less degenerate descendants, but to the true viking strain, that after millions of years finally flowered out in the highest of the Teleosts, the basses and the mackerels.

With such general ideas in mind our receptive visitor will now find meaning and inspiration in the legend

GANOID FISHES—LIVING FOSSILS

that dominates a series of groups, including the paddlefish, shovel-nosed sturgeon, gar pike, and bowfin. And he will readily see for himself how these relics of long bygone ages illustrate the general principles outlined above; how the paddlefish, retaining the sharklike body-form of the Old Gancids, has sacrificed the shining armor of his family and, scaleless, now preys upon helpless small creatures which it searches out with its marvelously sensitive paddle-shaped snout and engulfs in its capacious mouth; how the shovel-nosed sturgeon, a senile mud-grubber, grovels on the bottom and sucks in the reeking paste with its toothless lips; how the gar pike, a real old die-hard, proudly wears his shining armor of enamelled scales and, although too old for open warfare, still maintains the baronial right to make sudden forays upon the helpless caravans of fat-bodied carps.

Coming to the end of the Ganoid series, the visitor will inspect one of the most interesting of all the "missing links," one still alive, namely, the bowfin. Fortunately for himself, the bowfin has no particular value either to the epicure or to the angler, and ichthyologists are not numerous enough to make serious inroads upon his numbers. He is literally of a retiring disposition and ordinarily lies almost motionless, except for the slow waving of his elongate dorsal fin. The mounted

group, however, reveals the bow-fin in a livelier mood and portrays a scene of considerable dramatic interest. For it shows two of the nests, or oval depressions, that the bow-fin scoops out at the mating season; one of them occupied by a newly mated pair guarding the nest, the other by a lone male that seems to glower unpleasantly at the domestic felicity of his successful rival

Fig. 3.—The Bowfin Group.—This illustrates the nesting habits of this ganoid fish (*Amia calva*). On the left a pair of fish are spawning on a nest; at the right a male stands guard over the eggs. After Dean

At this point the visitor glances upward at another gleaming legend

TELEOST FISHES
Highest Types of Fish Life

and immediately enters a series of three-sided alcoves flanked by wall cases, along the east side of the hall. The series begins in a rather quiet way with the salmons, trouts, tarpons, herrings, and other descendants of the oldest families of the newer or teleost aristocracy. This alcove will (if a true Mæcenas of the Fish Hall ever materializes) be dominated by a mural painting on the wall above it, showing salmon leaping up the falls of a river on their long pilgrimage to the spawning grounds.

The next alcove sets forth the strange forms included in the order of Ostariophysi i e., fishes with a train of little bones connecting the air-bladder with the skull. Who would suspect that even the despised catfish, to say nothing of the lowly carps and suckers, would be endowed with such a marvelous and unique mechanism for transmitting sensory responses to slight differences in water pressure from the surface of the body to the organs of balance in the inner ear and brain? Or who would suspect from their appearance that the carps, with their protrusile toothless mouths, have an elaborate dental mechanism in their throats?

This alcove will some day (D. V.) be dominated by a mural showing a school of vicious little piranhas or man-eating fish attacking a floating mass that breaks the sunlight from above, while below several large black catfishes begin to move out from the mangrove roots in anticipation of the approaching feast.

The next three alcoves are devoted exclusively to the glorification of the latest and most beautiful models of the fish world—the basses, bluefishes, mackerels, crevallés, and their multitudinous relations. Among these families the history of the Old Ganoid stocks almost repeats itself. For here are the conservative types like the black basses, the progressive types like the bluefish and the mackerels, and numerous radicals and freaks, which fill the remaining alcoves and wall cases of the Teleost series.

The central forms, typified by the perch and the striped bass, inherit a peculiar assemblage of characters which crop out, in whole or in part, and beneath endless modifications in detail, in perhaps ninety per cent of all the species of fishes living today. As far back as Cretaceous times during the closing æons of the age of reptiles, the ancestors of the spiny-finned fishes appear for the first time in the known fossil record. Curious, short, deep-bodied forms they were, with their hind limbs (including the pelvic girdle and the ventral fins) firmly fastened to the lower part of their collar bones (or pectoral girdle). This swivel-chairlike arrangement, which is seen at its best today among the quick-dodging inshore fishes, is only one of numerous meritorious features that have enabled the spiny-finned forms to crowd nearly all the older types into out-of-the-way corners of the fishy world.

As to the future murals, which will form indispensable centerpieces on the walls above these alcoves, the one above the first spiny-finned series will depict the golden grouper of the Galapagos islands, gleaming amid the dark volcanic rocks and surrounded by his retinue of olive-green relatives. That on the wall above the wrasses and their allies will reveal one of the large and gorgeous parrot-fishes winging and steering his way among fantastic coral growths and accompanied by butterfly-fishes and Moorish idols, while the mural on the wall above the mackerels and their allies will represent a school of swift bonitos leaping and plunging like dolphins into the waves.

The last alcove on the east side of the hall is devoted to the most highly specialized and strangest of all the families of the spiny-finned order of Teleosts. The panel of the trigger-fishes will be surmounted by a mural showing the Bermuda file-fish—a spotted, kite-shaped thing with length and height but hardly any thickness, cheeks prolonged excessively downward and forward, a fixed stare and an impossibly small and scornfully upturned mouth.

But the prize exhibit of this alcove is the life-size model of a relatively gigantic sea devil, *Ceratias holboelli*, the original of which is in the British Museum of Natural History. As described by Dr. Tate Regan, this particular specimen was a female with a curious appendage attached to her throat, which upon close inspection proved to be nothing more nor less than a diminutive male of the same species, fully adult and apparently the mate of the giant female. The explanation offered by ichthyologists for this strange state, approaching semiparasitism on the part of the male, is that it is Nature's way of insuring the perpetuation of the

species, since, before this happy solution of the problem, the chances of lone wandering female sea-devils finding mates in the vast black spaces of the great deep were slim enough. But what the ichthyologists have not explained is how or why such a meek and inoffensive little male fish should ever become ambitious and rash enough to press his unwelcome attentions upon a giantess of such frigid and austere mien. In the present undeveloped state of psychoanalysis as applied to ichthyology, our own simple and direct hypothesis, submitted here for what it is worth, is that after the affair was fairly started, the rash little male had a very narrow escape from the cavernous jaws of his all-devouring bride, and that to save himself in one of her tantrums he caught her by the throat as she rushed at him; and being too much terrified to let go, has been there ever since.

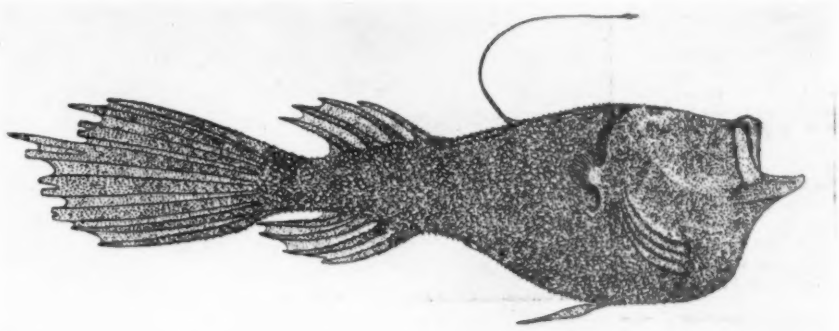
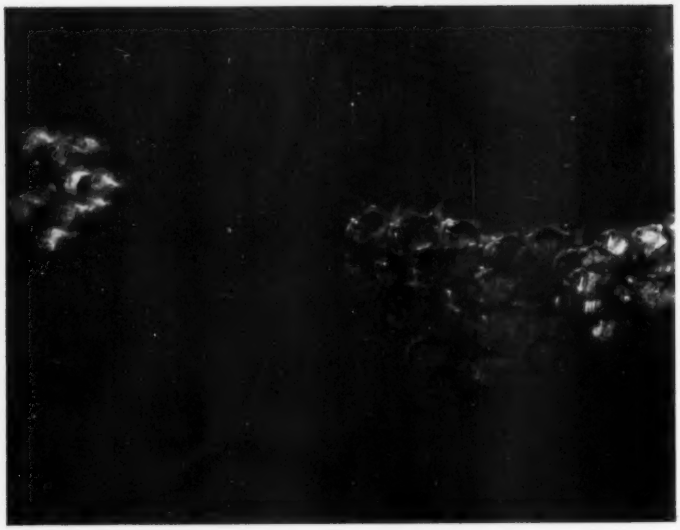


Fig. 4.—A female sea-devil (*Ceratias holboelli*) with the dependent, permanently attached, parasitic male fish. After Regan

A few steps more and the visitor will be facing the climax of the whole exhibition, the Sailfish Group, which is the centerpiece of the collection of Big Game Fishes. (For a reproduction of this in colors, see the cover of this issue of NATURAL HISTORY.) In the background the precipitous rocky islets of Cape San Lucas jut into the splendor of a southern California sky and tower above a choppy sea where ocean currents struggle. In the foreground a nine-foot sailfish is hurling his lithe body clear of the water. The sunlight flashes from his dripping flanks and purple sail, as in frantic rage he twists and shakes himself. But the cruel hook in his jaws holds fast and the thin line leads back to the boat near by, where the human partner in the duel pits his quick hand and unflinching will against the plunging weight of the maddened fish. We trust that when Mr. and Mrs. Keith Spalding of Pasadena, California, view this group it will bring back very vividly to their minds the scene when the fish was caught by their guest, Mrs. Addie C. Greenfield, on their yacht the "Goodwill" in June, 1925. It was due to their hospitality that Mr. Walter Escherich of the Museum's department of preparation was present on that occasion, and was enabled to secure full color notes, casts, exact measurements, and a properly prepared skin as a basis for his highly lifelike mount of the fish itself. And it was due largely to their further interest and generosity that the striking background was painted by Mr. Frank J. MacKenzie.

The whole north wall of the hall is

NEPTUNE'S FIREFLIES
In the open seas of the Atlantic and Pacific incredible numbers of small lantern fishes (*Myctophum coccoi*) live in the daytime at considerable depths, but come up to the surface at night, and may be caught in fine-meshed tow nets. Rows of phosphorescent spots appear on the sides and on the head. The lights enable the schools of fish to keep together and serve to attract the swarms of minute shrimps upon which the fish feed. The lights are also used as lures by larger fish to attract the smaller kinds. *Astronesthes*, the fierce enemy of the Myctophids, follows them in their nightly journey from the depths and drives them furiously before him



Figs. 5 and 6

BLAZING JEWELS
The silver jewel fish (*Argyropelecus*) lives far down where the last feeble light from the surface merges into the blackness of the ocean depths. Like grand court dames arrayed for a royal fête, these pompous little creatures wear their silver robes and flash their dazzling jewels. Foolish shrimps, attracted by this display, crowd nearer, while the sly jewel fish, with bulging eyes turned loftily upward, moves up quietly below the shrimp and suddenly engulfs it

hung with fishes that are far bigger even than those that get away from most fishermen. The gigantic ocean sunfish, the huge tunas, marlins, and swordfishes, and all the others are the hard won trophies of Mr. Zane Grey, the well-known author and Nimrod of the Seas, to whom the Museum and the Museum public are indebted for this splendid collection, which is described in a special article (page 93).

Adjoining the Zane Grey collection are several other cases containing some fine examples of fresh-water and surf fishes presented by Mr. S. W. Eccles, the late Jacob Wertheim, and others. Mr. Van Campen Heilner, the field representative in charge of the Game Fish collections, plans to install near by a bulletin board containing a current list of "Record Fishes." Mr. E. R. Hewitt is developing an exhibit illustrating the history of fly fishing in England and America which he has presented for the Game Fish Collection. It is hoped that other donors will

Fig. 7

THE DRAGON STRIKES
The black night of the ocean depths cannot hide the peaceful big-heads (*Melamphaes*) from their cruel enemy the dragon-like *Chauliodus*. While they are wandering in the vast spaces he draws near. Now he strikes—but misses them in the wild confusion of flight

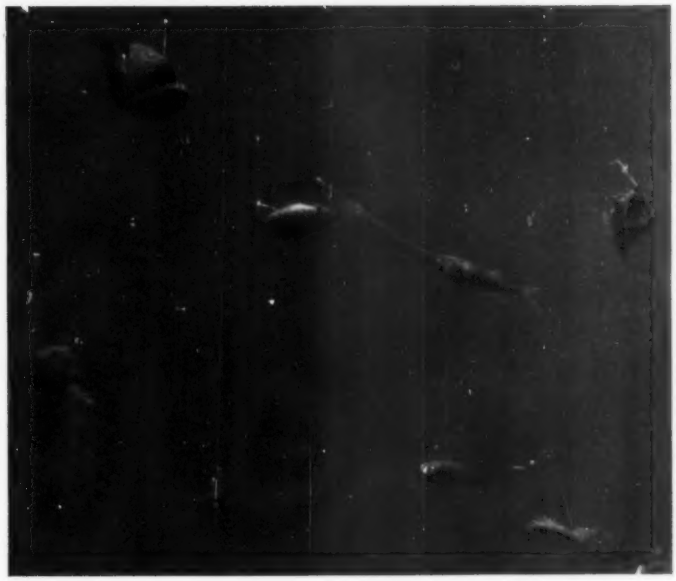


Fig. 8

LITTLE SEA DEVILS
The mediæval imagination never pictured imps of darkness half so grotesque as these. But despite their terrifying exterior the little sea devils are no worse than human fishermen who attract fish with a light and scoop them into a trap. Only in this case the light is a bit of luminous skin dangled on a slender bony rod held over the trap, and the trap is the little sea devil's enormous mouth set all around with needle-like teeth

come forward with early copies of Isaac Walton or other classics for our future exhibit on the history of game fishing from the days of the cave men to modern times.

Turning now to the west side of the hall, our visitor comes to the biologic exhibit, which is installed in two long wall cases. In the first of these, when it is completed, he will find a series of enlarged models illustrating the embryonic development of various kinds of fishes, based largely upon the materials and observations of Professor Bashford Dean, the first curator of the department, now honorary curator. In the Port Jackson shark, a "living fossil," the last survivor of an ancient

group of sharks, most of which died out in the Age of Reptiles, the development of the embryo is extremely slow, requiring probably not less than seven or eight months. Here the eggs laid in any one season are very few, but each is endowed with a huge mass of low-grade capital in the form of yolk. When the young shark is finally ready to break through the shell, it is almost like a small edition of its parents and is ready to carry on life in almost the same way. At the other extreme, in some of the higher teleosts, the capital endowment is spread over several hundred thousand minute eggs, which develop very rapidly into tiny larvæ quite unlike their parents, and feeding upon entirely different food. Thus, while the well endowed patrician shark-young are fed from the capital left by their parents, the swarming proletarian teleost larvæ must earn their own living from infancy and must be sacrificed in millions to the rapacity of other animals.

A second panel of this exhibit will deal with parental care among fishes, illustrating the subjects of nests and nest building, the care of the young in brood-pouches, and the self-denying behavior of certain catfishes, which (as vouched for by our own Doctor Gudger) zealously guard the eggs while holding them in their mouths during the entire period of incubation.

Fig. 9.

BLACK PIRATES

These deep-sea pirates are not snakes but "degraded eels," that have lost almost everything but their voracious appetites. One of them has just swallowed a fish that is bigger than himself, which stretches him nearly to his elastic limit. His less fortunate mate, yawning fearfully, opens the dark gateway to his cavernous interior

The third and fourth panel will show the amazingly diverse mechanisms of the jaws and teeth of fishes together with the crushing and grinding apparatus that some fishes carry in their throats. The fifth and last panel in this case will show the different forms of the digestive tract in flesh-eating and herbivorous fishes.

In the second wall case of this biologic series the visitor will note in the center an array of fishes of widely

different body forms, that range from the excessively elongate snipe-eel to the very short but high Moorish idol, and from the extremely wide, flat angler-fish to the extraordinarily thin moon-fish. In the next panel he will see how a long-bodied fish slips through the water by waving its whole body like a flag in the wind; how the skates use this same principle in flapping their wings; how the short, stiff-bodied trunk-fish wags along by means of its tail; and how such a normal bodied fish as a crevallé stands midway in its method of locomotion between the eel and the trunk-fish. Here also the visitor will see the mechanical models with which Mr. C. M. Breder, Jr., of the New York Aquarium, who is also a research associate in this department, has been able to reproduce the principal body movements of fishes. From all this, the visitor will readily comprehend how easily an eel, with its long, low head and snakelike body, slips through the water, and why the opposite combination of characters, short, very high body. steep forehead and wide-spreading pectorals, combined with small nipper-like jaws is favored by fishes that require a firm stance to pluck their food from the solid reefs.

Another panel of this case will, when completed show how the most diverse body-forms of fishes conform to streamline curves that offer a minimum resistance either to currents or to forward locomotion. Here also the visitor may learn in how far fishes and ships are built on the same principles and in what others they differ radically.

From the biologic exhibit the visitor may enter the large inner room that contains some of the most noteworthy of the mounted groups. The future centerpiece of this room will be a scene of tropical fishes, probably the reef fishes of Hawaii. Moorish idols, like high, flexible triangles, with broad vertical bands of black and yellow, and long wisps trailing from the upper and lower corners, will float unconcernedly above a great open-jawed serpent-like moray, spotted like a harlequin and writhing horribly. Fatuous looking trigger-fishes of impossible color combinations will be bustling around, their faces smugly complacent, like libellous caricatures of obese statesmen. Bejewelled parrot wrasses will flaunt their gaudy array like revellers in a pagan festival, while the silvery carangoids, spiralling down from the blue above, will look with appraising eyes, searching for their victims among this riot of mad colors and wild forms.

The next group will offer a wide contrast to this for it will be a study in dark colors and grays, with the somber battlements of submerged volcanic rocks in the Galapagos Islands for a background. Behind a narrow cañon between two great rock masses pale shafts of light stream down, lighting the rear guard of an army in motion. Forward through the gap and into the open, it winds its way, a drifting Milky Way of winged hosts of drab and frowning *Xesuri*,[1] waving their yellow tails like banners. Just one scene in a crowded day under water, but a scene that will not cease to haunt us until we can bring it to life again in the Hall of Fishes.

In this large inner room there is hung a series of color drawings of deep-sea fishes collected by the "Arcturus" expedition. with some of the original specimens mounted in square glass jars. Near by are enlarged photographs of deep-sea dredging machinery in operation on the "Arcturus." For all

[1]For a colored figure of *Xesurus* and a lively account of its behavior, see William Beebe "The Arcturus Adventure," New York, 1926, chap. XI, pl. VI.

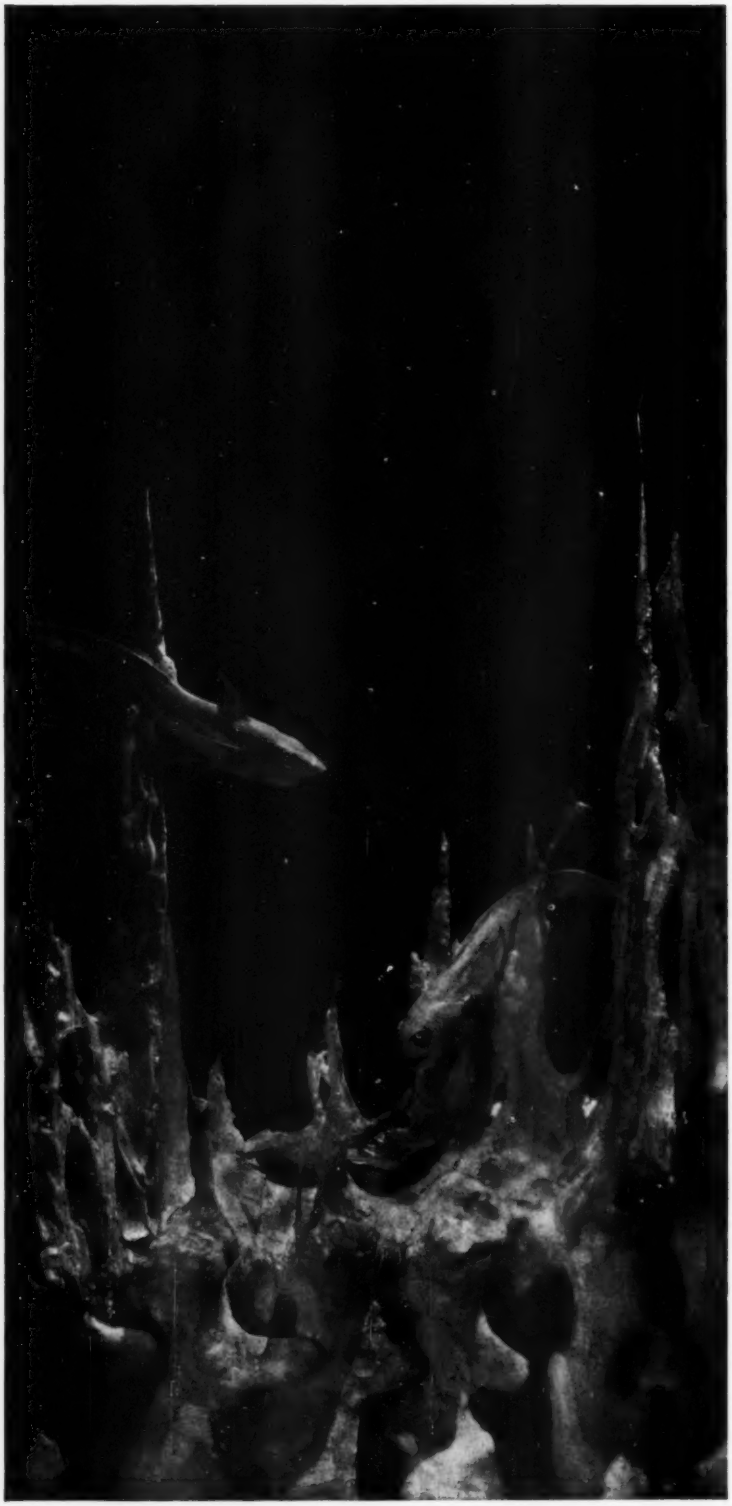


Fig. 10

WANDERING GHOSTS

Like some long forgotten wreck the carcass of a great whale lies sprawling on the ocean floor, and like famished ghosts of shipwrecked sailors the pallid ratfishes wander to and fro amid the wreckage.

Figs. 5–11 are reproductions of the seven panels of Deep Sea Fishes in the darkened chamber occupying the northern end of the central inclosure in the Hall of Fishes. The seven groups represent, from left to right, a descending series of zones of fish life, and end with two panels showing fishes swimming around the skeleton of a whale on the ocean floor a thousand fathoms deep in the Country of Perpetual Night. The legends given under the seven figures are the labels which the visitors will find under the respective groups

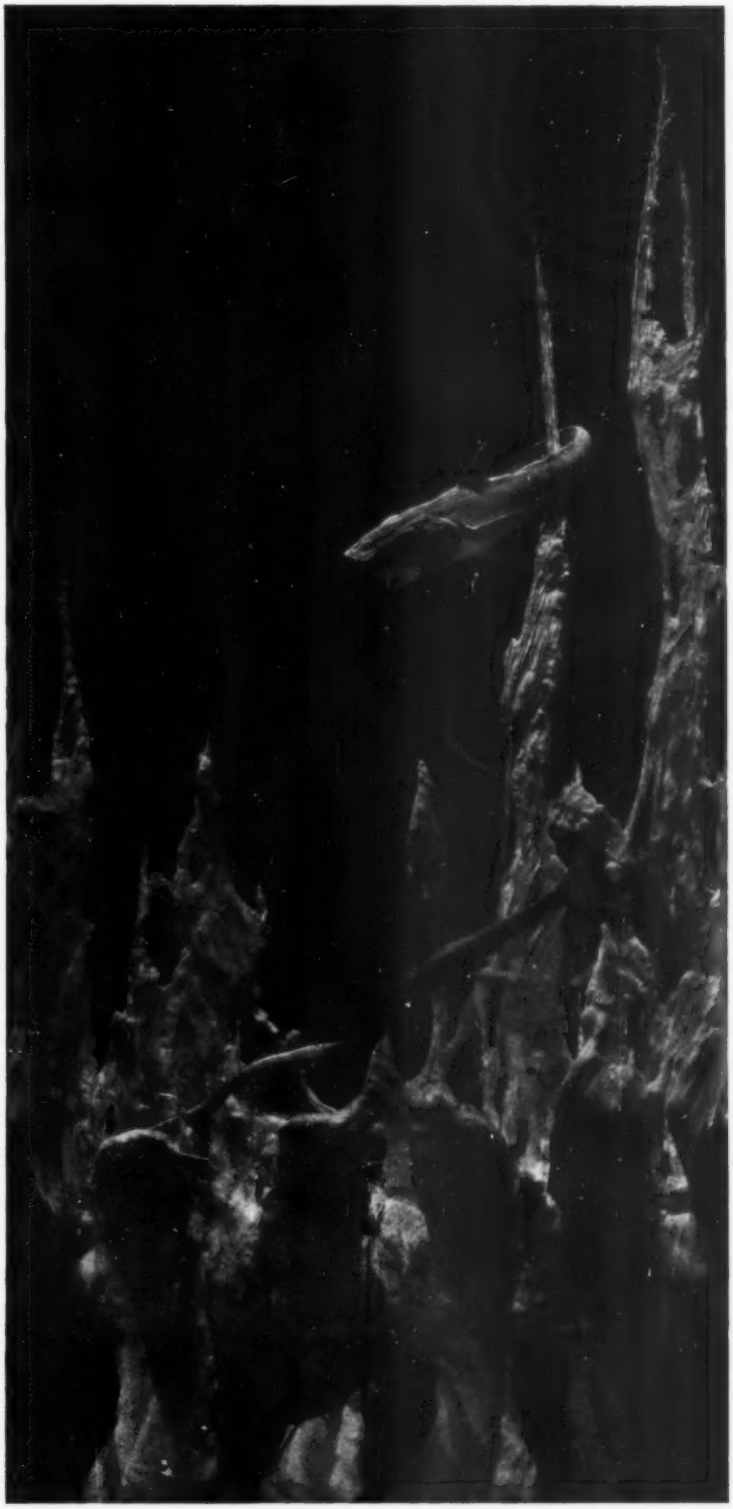


Fig. 11

THE COUNTRY OF PERPETUAL NIGHT

The Country of Perpetual Night lies at the bottom of the ocean a thousand fathoms deep. Its inhabitants are hobgoblins, fearsome shapes that writhe and dart in and out in the midst of a fantastic Garden of Death. Gleaming serpent forms, blind creatures that crawl and grope in the darkness, black living masses, horrible and cold to the touch, they look at first like evil spirits condemned by some wicked magician to live in this desolate purgatory. But when Science holds up for us her crystal lens, the scene loses its terrors, and we see each quaint hobgoblin as it really is—a miracle of design—fitted to live in the midst of inconceivable pressure and able to find its own mate in the loneliness of Perpetual Night

this we are indebted to the New York Zoological Society and the unfailing interest of Mr. William Beebe.

In the center of the "Arcturus" exhibit a doorway leads to the groups of Deep Sea Fishes designed and modeled by Dwight Franklin. This beautiful exhibit is arranged in seven panels and represents from left to right a descending series of zones of fish life. The original materials and data for these groups were for the most part collected by the "Arcturus" expedition in the Pacific Ocean in the neighborhood of the Galapagos Islands Since deep-sea fishes are as a rule excessively flimsy in structure, it is not practicable to make satisfactory mounted skins of them for a group so that we have used very accurate models colored from the paintings made by the artist of the "Arcturus," when the specimens were either still alive or but very recently dead. On that memorable voyage special efforts were made to study as many as possible of the light-bearing fishes when alive; and in the photographic dark room and laboratory of the vessel many observations were made on the appearance of living fishes from considerable depths, that have been utilized in the planning and preparation of the present museum groups. Our first care has been to convey some sense of the vast and utter blackness of the environment in which these curious creatures live, and our visitor will probably feel that in this Mr. Franklin has been highly successful. Our second difficulty was to find fishes that were large enough to be easily seen without a magnifying glass, for, out of the many thousands of deep-sea fishes dredged by the "Arcturus," extremely few were longer than one's little finger. This is possibly due in part to the fact that, because of the low temperatures and the darkness in which these fish live, the rate of growth from the minute fertilized egg to the fully adult stage is exceedingly slow, and most fishes get eaten up long before they can attain the large size of such great rarities as the fifty-four inch "gulper" described by Harwood in 1827, which we have chosen to model for the centerpiece of the entire series.

The seven panel-groups of deep-sea fishes above referred to are shown herein as Figs. 5 to 11, from photographs by Messrs. Rice and Dutcher of the Museum staff.

The discerning visitor will realize that we have of course spared no pains to make our groups accurate as to essential facts; also that in our labels we have endeavored to divest the subject of its technical aspects and to present it to the public in language and symbols that will stimulate human interest in the lives and tragedies of the dark underworld of the ocean depths. For those who may be interested in the broader and more scientific aspects of the subject the following label is provided:

DEEP-SEA FISHES

Fishes that live at great depths have to be able to endure enormous water pressure, low temperatures (near the freezing point), and total darkness. At one mile depth each square inch of surface of a fish's body is under a pressure equal to the weight of a column of water a mile high and with a base one inch square. But the pressure is equal in all directions. It permeates the whole fish both inside and outside and evidently does not injure the most delicate tissues.

Deep-sea Fishes have been derived from the most widely different kinds of shallow-water fishes and differ almost as much as these do in appearance and form of body; but many deep-sea fishes are flimsy in build and more or less eel-like with pointed tails. The vast majority are quite small, because

food is scarce and growth in the intense cold is very slow.

All deep-sea life is dependent ultimately upon the rain of food-bearing particles from the richer waters of the surface. The countless myriads of microscopic plants are absorbed by the microscopic animals, and these by the billions of tiny copepods and shrimps which in turn are devoured by the ravenous small fishes.

Many different kinds of deep-sea animals have the power of making a phosphorescent light. Among the fishes, the surface of the body is often studded with little glow lamps. Each tiny lamp has a lens, a reflector, and a gland for producing a substance called luciferin which emits a light when supplied with oxygen from the blood. The little shrimps and other creatures upon which the fish feeds are attracted toward the lights as the moth is to the flame. The lights also enable fishes of the same kind to find each other and keep together in schools.

The departing visitor will probably linger a while longer, examining the remarkable series of water-color paintings of the strange fishes that were collected by Mr. William K. Vanderbilt during a recent cruise to the Bahamas and Galapagos Islands. The fishes were painted while still fresh by Mr. William E. Belanske. These pictures, which have been presented by Mr. Vanderbilt, are mounted on screens on either side of the main entrance.

In the light of all he has seen today, our visitor will no doubt enjoy the beauty and truth of the following illuminated verses, which were composed especially for our Fish Hall by poets who are distinguished for their ability to sense and to make audible the subtle harmonies of the ocean.

UNDERSEA

This so-called dark and silent undersea,
What if its colors throw off sound and song?
What if this seaweed's waving forestry,
These buoyant folk that swim the depth along,
Were choral as the birds among their branches?
And if these burnished scales that specialize
Past sight and sound in their unfathomed ranches
Find wonder that eludes our ears and eyes?
What if this sea were rhythmic with a story,
Not earth's, but only differing in glory?

ISABEL FISKE CONANT

They move and have their being in the vast
Ocean that teemed before the land was green;
They keep the secret of the farthest past;
Children of water, silent and serene.

SARA TEASDALE

The Habits and Life History of *Lophius*, the Angler Fish

By ULRIC DAHLGREN

Professor of Biology, Princeton University

AMONG the several groups of highly modified fishes which have, in the ages, developed from some branches of the fish family tree, none is of higher interest or of more decided specialization than the order *Pediculati* or angler fishes. Certain technical features, nearly always present, and certain other general ones may serve to define this group.

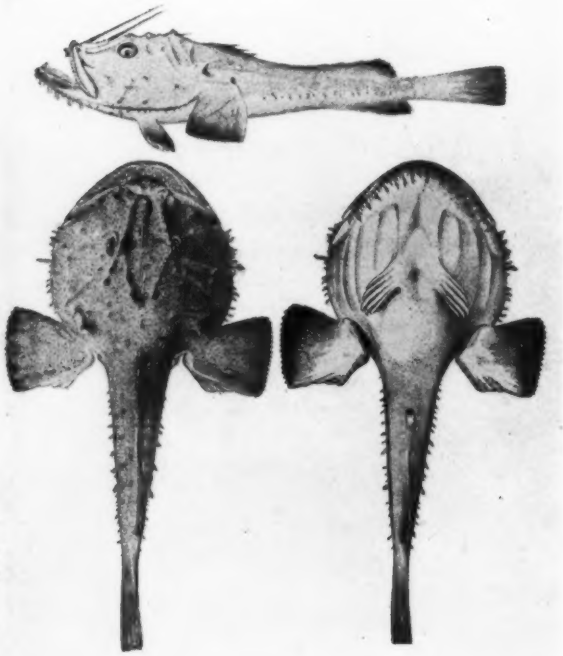


Fig. 1.—The American angler or fishing frog, *Lophius americanus*, in side, top, and bottom views. After Goode and Bean, Oceanic Ichthyology, 1895

The first of these technical features is indicated by the Latin name *Pediculati* which was given to the group because the pectoral fins, which correspond to a man's arms, a bird's wings, or a dog's front feet, do not emerge from the body directly as in most fishes, but the base has grown out into a fleshy *pedicle* that is analogous, and also in a measure homologous to our arm—a short arm, but one by which the fish can be seized and lifted from the water, or around which a rope may be tied to "anchor" the creature to a dock or a stake. The bony and muscular elements of this pedicle or arm are present in most other fishes but do not show usually and sometimes appear to be entirely absent.

The second feature (usually present in the various members of the order) is a modification of the first dorsal fin in which the posterior fin rays have become small and weak while the first anterior ray has become long and stiff and has developed on its tip an enlarged bit of flesh covered by a modified integument. This tip organ is usually called the lure or bait and is colored yellow or whitish, and has in some cases developed glands which secrete mucus or even have the power of luminosity in some of those members of the order that have adapted themselves to a deep-sea life. In one group, the bat fishes, this first dorsal fin ray is re-

duced to a short knob that may be retracted into a cavity. This first ray in all the forms has a jointed base and strong muscles to move it backward or forward, and it is commonly supposed that the fish uses it as a "fishing rod" to lure small animals near to or into its mouth where they may be caught and swallowed.

As for general features, we find those which tend to unite the group and others which have caused it to be divided into five main subdivisions. The members of the family are nearly all predatory, capturing other animals, principally fishes, and swallowing them whole, while some of the bat-fishes grub in the mud for food. As a rule the head is usually large and, together with what may be called the shoulders, forms the greater part of the body. Further, these fishes have a large mouth armed with long, sharp teeth and a wide throat. The stomach is so distensible that the fish can swallow other fishes nearly as large as itself.

In motion they are all very slow and usually move about but little. When moving they swim but languidly, and those kinds that live in contact with the bottom or on seaweed use the armlike pectoral fins almost like hands, as in a crawling animal. Consequently the body is soft, the muscle masses not large, and the general form does not have to be of the stream-line shape with large, hard muscles, so well shown in swift swimmers like the mackerel, swordfish, and striped bass.

This order has been divided into five families, but it is the writer's intention to confine this article to the first and best known of these, the *Lophidæ*, and especially to the angler *Lophius piscatorius*.

GENERAL CHARACTERS AND HABITS

The Lophidæ are the least specialized of the families and seem to represent most closely the stock from which they and the other families were derived. They form a homogeneous group which has been subdivided into only a few genera, and comparatively few species are known. These are widely distributed, being found in most north temperate and some tropical seas, and are alike in being fish of fair size, living in water of usually moderate depth although sometimes found in depths that almost entitle them to the term "deep-sea fish." The prominent member of this group is the large fish known as "angler" (Fig. 1) in England and found on both shores of the Atlantic, ranging north from Cape Hatteras on the American side and from the Mediterranean on the European coast. Its northern limits probably extend to the northerly parts of Scandinavia, and to Newfoundland and the Grand Banks. To the south, on the American coast it extends, in the deeper waters only (down to 350 fathoms), at least as far south as the West Indies.

The angler is a classic fish as can be understood when one sees it. So grotesque, so monstrous and so sinister in appearance is it, that it attracts the attention at once and is not easily forgotten. It is recorded in the literature of all ages, having been first observed and described by Aristotle under a Greek name which means a froglike fish. He observed the enlarged and specialized front ray of the dorsal fin and its filament (lure) and supposed that this was used for attracting its prey.

Wherever seen, its ungainly and grotesque form or peculiar habits have earned for it a new or a repeated old name until its synonymy has included such names as "angler." "fishing frog," "wide gape" (England); "monkfish (Maine); "goosefish"

(Massachusetts); "bellowfish" (Rhode Island); "molligut" (Connecticut); "allmouth" (Carolina); and from fifty to seventy-five other names in English and foreign languages. It is quite probable that the western Atlantic or American fish is a well defined variety of or even a different species from the European *Lophius piscatorius* and it has been named *L. americanus* by several authors. In this article, however, we will speak of both of them indiscriminately as *Lophius* or the "angler" unless otherwise stated.

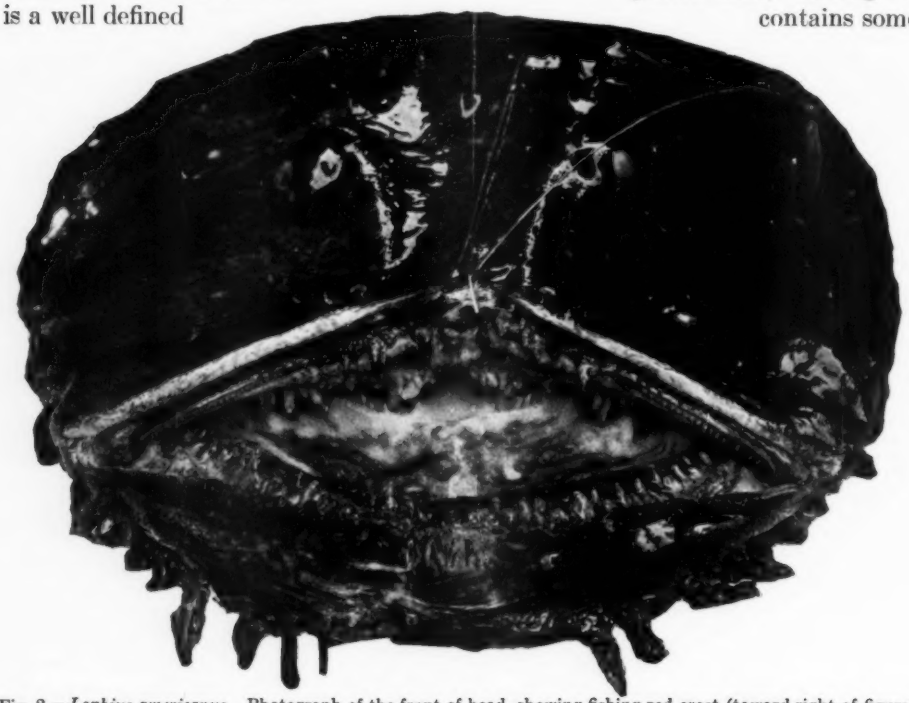


Fig. 2.—*Lophius americanus*. Photograph of the front of head, showing fishing rod erect (toward right of figure) with lure depending. The mouth is half open, showing teeth with membranous covers. Photographed at Salisbury Cove, Maine, by Dr. D. S. Johnson

When one sees the fish (Figs. 1 and 2), the first impression perhaps is that of its enormous head and wide mouth and the comparatively small tail and caudal fin. One next notes the flattened form of the body, adapted to lying on the bottom, and then its mottled brownish color with numerous rough projections and filaments of skin that wave about in the water and give it the appearance of a flat, dirty stone or bowlder on which much short seaweed is growing. This impression is so well expressed by the Duke of Argyle that a part of his account of the fish will be quoted here, although it contains some features that have not yet been scientifically proven. He writes:

> It is adapted for concealment at the bottom of the sea—for lying perfectly flat on the sand or among the weeds—with its cavernous mouth ready for a snap. For more perfect concealment, every bit of the creature is imitative both in form and in coloring. The whole upper surface is mottled and tinted in such close resemblance to stones and gravel and sea-weeds that it becomes quite undistinguishable among them. In order to complete the method of concealment, the whole margins of the fish, and the very edge of the lips and jaws, have loose tags and fringes which wave and sway about amid the currents of water, so as to look exactly like the smaller algæ which move around them

and along with them. Even the very ventral fins of this devouring deception, which are thick, strong, and fleshy, almost like hands, and which evidently help in a sudden leap, are made like two great clam-shells, while the iris of the eyes is so colored in lines radiating from the pupil as to look precisely like some species of *Patella* or limpet. But this is not all; not only is concealment made perfect to enable the *Lophius* to catch the unwary, but there is a bait provided to attract the hungry and the inexperienced. From the top of the head proceeds a pair, or two pair, of slender elastic rods, like the slender tips of fishing-rods, ending in a little membrane or web which glistens in the water and is attractive to other fish. When they come to bite, or even to look, they are suddenly engulfed, for the portals open with a rush and close again—portals over which the inscription may be written: *Lasciate ogni speranza voi che' entrate!*

The fish so vividly described above, and shown in lateral, dorsal, and ventral views in Fig. 1, is about three feet long and weighs in the neighborhood of thirty-five or forty pounds. Its flesh is very soft and flaccid and its outer surface exceedingly slimy. Few other fishes can give off the enormous quantities of tough, tenacious mucous secretion that this fish can. When undisturbed, the slime is not so apparent, but when hauled out on the deck of a boat and handled, and especially when killed and dissected, it leaves layers of mucus that are sometimes a quarter of an inch or more in thickness and very tough and hard. If plenty of water is supplied, this slime, which is at first opaque mucigen, absorbs the water and becomes the completed mucus, more voluminous and transparent and of course softer.

The creature's swimming powers and motions are slow but powerful. It swims by a curving stroke of its tail and caudal fin and if caught on a hook or tied by a rope can exert a considerable pull. The tail strokes are about one a second in each direction but can be increased four or fivefold when the animal is seized. It swims thus, off but near the bottom in its migrations which are done in easy stages, and it moves about in short trips from place to place quite often, as is evidenced by its getting into the fish traps frequently. When in such traps it is worried, and swims slowly about nosing the twine in an effort to find its way out, which it effects in a greater number of cases than the swifter-swimming mackerel and herring that pass these avenues of possible escape in their hurry and fright. Most of the angler's time however, is spent on the bottom, where it selects a rocky or gravelly bed on what is known as good fishing ground. Here it sometimes moves about, using both tail and a nudging movement of its armlike pectoral fins. Then it settles in some spot and waits for its prey, inert but watchful, over long periods of time.

FOOD AND FEEDING HABITS

We have but few reports based on actual observations of the way in which the angler secures its food. Most of our knowledge of its feeding habits comes from examining the contents of the stomach of the freshly caught fish. We thus learn that it feeds on a large number of animal forms, mainly however on other fishes as haddock, herring, dogfish, flounders, sculpins, etc., some of very considerable size but many surprisingly small compared with their captor. Furthermore, it often captures and swallows invertebrates of various kinds, especially such as move about on or near the bottom—squid, lobsters and crabs, and large swimming worms. Less often, but not infrequently, we find that the angler has caught and swal-

lowed sea fowl of several kinds. Seven wild ducks have been taken from the stomach of one individual, a wild goose has been found engulfed, and one fisherman has seen the struggle on the surface between a loon and the angler that had seized him by the head and neck and was engaged in pulling him under to drown and swallow him. Gulls are more often found in the stomach, and on several occasions *Lophius* has been known to show an entire lack of discriminating taste by swallowing the wooden buoys of lobster pots, thus annoying the fishermen.

Thus we see plainly that *Lophius* does not always wait on the bottom for his prey to come to him but is capable of slowly swimming and sneaking up beneath even large surface birds and seizing them by feet or head and swallowing them. It is also probable that, when but few fish are coming to his waiting jaws on the bottom, he will attack by stealth any slow-moving fish or other animal that may come within sight. No one has actually seen one of them thus engulf a fish nor has one been seen to eat when confined in an aquarium. He makes a poor aquarium subject since he refuses all food in captivity, and hence does not live long.

Since the fish seldom comes into water shallow enough for observation, but is usually caught at a depth of thirty or more feet, we are debarred from direct studies of its feeding habits. It has always been inferred, probably with some accuracy, that the fishing rod and lure were used to entice other fish to approach near enough to be caught. Aristotle stated this and countless observers since his time have had the same idea—the matter seems so obvious. Probably it is true and we have one observation that seems to confirm it. One observer who had a fish in captivity touched the lure with a broom handle. The lure was moving back and forth and whenever the broom handle came in contact with the lure the fish gave a gulping snap with its huge mouth and accurately seized the stick at the region where it had been in contact with the lure. This would indicate a very active and delicate reflex. Dr. Homer Smith has thus experimented on a *Lophius* but it was in poor condition and no accurate results were obtained.

The lure is attractive to small fish and the writer has used it as bait to prove that it will be attacked by them, numbers having been caught in this way. It is of a light yellow color, very different from the general color tone of all the rest of the body and would thus attract the eye. The "rod" or anterior dorsal fin ray on which the lure is placed is thin and stiff and at its base is provided with a series of muscles that move it back and forth from a posterior position in which it lies flat against the body, to one that is erect but leaning forward so that the lure hangs over the mouth (see Fig. 2). This would be its natural position in "fishing."

The mouth is of extraordinary size with the gape almost as wide as the head, and both upper and lower jaws are armed with a multiple row of very strong, sharp teeth of various sizes that curve slightly backward and appear to be capable of holding anything on which they may be set (Fig. 2). The jaws are so arranged that this mouth is capable of quick and accurate "gulping" like a dog.

Lophius does not disdain dead objects. It is caught constantly on small baits of chopped herring and shelled clams and is an occasional captive on the trawler's hooks. Hand-liners fishing with hook and sinker frequently

capture it. The writer caught three in this way off South Harpswell, Maine, in a single fishing trip, in about thirty-five feet of water. These fish were almost fully grown, about thirty pounds in weight, and although the hooks (baited with clams for small cod) were small and the lines thin, the fish were pulled up slowly, making a continuous heavy resistance, but were easily secured with the gaff. The comparatively tiny hooks, the clam bait, and the thin lines looked ridiculously small to catch these large fishes, and one could but wonder at their having noticed so insignificant bits of bait. Nothing large or small seems to escape their attention, however.

Fig. 3.—*Lophius americanus*. A small living adult (24 inches) in a tub of water. The fish had been tethered at the dock over night. The regions denuded of skin by starfish and sea-urchins show plainly as white areas on the right side of the head and the body. Photographed at Salisbury Cove by Dr. D. S. Johnson

Strange to say, the digestion of this fish seems to be unusually slow. We would expect to find a quick, strong, acid, pepsin digestion in such a voracious carnivorous animal. And this may be true in nature The fact remains that several persons have reported finding fresh fish that hardly seemed to have been touched by the digestive juices in its stomach hours after the fish had been brought to market.

In most carnivorous fish digestion goes on rapidly for a considerable time after the capture and even after the death of the animal, but we have many reliable reports of fish taken from the stomach of *Lophius* that were so fresh that they were sold in the market. Thus a man once sold a half bushel of herring so obtained. Dr. E. K. Marshall, at the Mount Desert Island Biological Laboratory, lately found a haddock twenty-two inches long in the stomach of a *Lophius* twenty-nine inches long. This was in apparently perfectly fresh condition, and there were no marks of teeth or of distortion or digestion although the *Lophius* had been caught at sea early in the morning, transported sixteen miles over land in a tub of salt water, and had had the haddock in his stomach for at least two days while he was tethered at the laboratory dock, alive.

PARASITES AND ENEMIES

Owing to its sedentary habits and its animal food, we might expect *Lophius* to harbor many parasites. This is found to be true, but strange to say, where we might expect to find many ectoparasites and commensals on his soft outside skin with its many crannies and appendages, we find but few. Occasional trematodes and leeches are found, but never the large copepods, and seldom the flat "fish-lice" and smaller copepods so common on the body and in the gills of fish that live a still life. This is probably due to the large secretion of mucus by the skin, which acts as an automatic mechanical cleaner, a fact that is more or less true of all bony fishes. It may be that the skin also secretes some extra poisonous or offensive substance that discourages such visitors.

As to internal parasites, we find large numbers of tapeworms, trematodes,

and above all, nematode worms, which enter by way of the mouth in the bodies of its prey, and may be found in the walls of the digestive tract, in the tissues of the internal organs, especially the liver, and in the connective tissues lining the body cavity.

A very interesting fact in connection with attacks on the fish's exterior has been observed by the writer both in free and in captive anglers. A number of these fish were brought in alive to the Mount Desert Island Laboratory for physiological experimentation. Each one was confined in the sea by tying a rope around one pectoral fin (or "arm") and tethering it to a stake or post on the floating dock in front of the laboratory. The water here was from ten to twenty-two feet deep and the fish had plenty of rope so that they could move around for a distance of 20 feet in any direction. The fish actively swam about or lay quietly on the sandy or muddy bottom for longer or shorter periods. This bottom was inhabited by some starfish (*Asterias forbesi* and *vulgaris*), and sea-urchins (*Strongylocentrotus drobachensis*), which were rather widely distributed and ordinarily not much in evidence. After a *Lophius* was thus tethered for twenty-four hours, large numbers of the starfish and some sea-urchins were found to have crawled on to his back. Here they clung fast and soon ate the outer layers of his skin, the starfish applying their stomachs and digesting the skin while the sea-urchins gnawed it off in smaller patches (see Fig. 3). When once attached by their ambulacral feet, the starfish and urchins are not easily pulled off, and it does not seem possible that *Lophius* can shake or rub them off unaided.

A *Lophius* would be able to live under these circumstances for only a few days and two questions at once arise; why was he unable to defend himself against these attacks when he could swim with almost normal freedom, and second, what does *Lophius* do in his natural habitat to protect himself against these enemies? He is supposed to remain lying on the bottom for long periods, waiting for his prey, and such a habitat abounds in starfish and sea-urchins. It is notable, however, that when tied to the dock he was farther inshore and in quieter waters than he is ever found in when free, and it is possible that when free he carefully avoids the vicinity of the starfish and sea-urchins.

In this connection the writer has observed, and many intelligent fishermen have told him, that in October and November considerable numbers of large adult *Lophius* come into shallow water and appear in the bays and coves, swimming very feebly and nosing into the beach where they are left to die stranded by the retreat of the tide. The popular opinion is that these are fish that have been enfeebled by old age, and that they come ashore to die. They often show the same ragged patches of denuded skin seen in those that have been attacked by the starfish. So many die in this way each fall that their bones, particularly the characteristic mandibles with their long sharp teeth, are one of the commonest objects seen on our beaches, lying above the high-water mark, dry and bleached, where they have been thrown by the winter storms. The writer advances the theory that, when *Lophius* comes into the shallower coastal waters in response to the seasonal changes and in pursuit of food, he is here often attacked by the littoral starfish and urchins and so weakened that he dies. Specimens captured on

the outer fishing grounds never show traces of this condition.

BREEDING HABITS—THE EGG RAFT

Most specimens of *Lophius* taken in our Atlantic waters from Nova Scotia to Virginia are of large size, three feet or more usually, but occasionally one will appear that is not much over a foot long. However, one is much puzzled to conjecture where their young may be. The young of many other fish may be seen swimming along shore when mere "pin heads," or coming up into the shallow water in late summer, especially toward night, sometimes in countless thousands. An evening's seining on a sandy beach at Nantucket, Massachusetts, furnished young mackerel, kingfish, gurnards, flounders of several species, young bluefish, scup, herring, and many other young fishes, but never a young angler!

Even the professional fisherman can give no information on this subject. And the average professional naturalist can say with the observing fisherman that he has seen only two stages in the fish's life history, the grown adult and the eggs, the latter noticeable because they form a huge "purple veil" or ribbon or raft of jelly that is about 30 feet long, 2 or 3 feet wide, and only 3 millimeters in thickness. This is occasionally seen floating about in the open sea or caught on some fisherman's net or line.

The mystery of the breeding habits of *Lophius* has been largely solved, however, partly by casual observations, but mainly by the hard work of such scientists as Agassiz, Whitman, McIntosh, Prince, Bowman, Lebour, Schmidt, Stiasny, Tåning, and many others. In brief it may be summed up as follows:

The fish does not breed in shallow or in brackish water, but goes off shore to deeper haunts and lays its eggs on the bottom of the open sea. The two ovaries of the female are peculiarly constructed for this purpose. They form two wide, long, and thin-walled tubes,

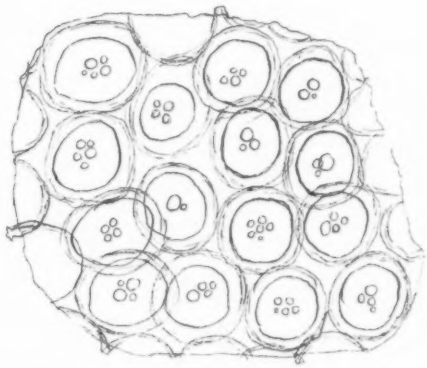


Fig. 4.—*Lophius piscatorius.* A small bit of "veil" with numerous eggs—much magnified. The completed veil will have from one to two million eggs. Original

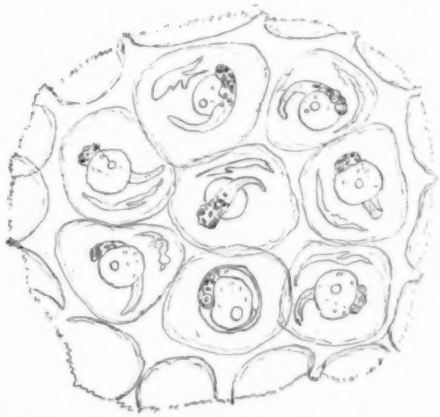


Fig. 5.—*Lophius americanus.* Newly hatched larvæ still in the jelly of the "veil." They have broken out of the egg capsules but will stay for a day or more in the jelly of the veil. One egg membrane is not yet ruptured. Original

much folded up in the body cavity and the two opening to the outside by a single orifice separate from and behind the opening of the intestine. Each tube on one side of its length is given over to the production of numerous eggs that mature in thousands of small papillæ. On the other side we find a surface that is studded with mucous glands so that the egg-producing papil-

læ are always pressing against the mucous secreting surface. When the ripe eggs, which are usually situated in or near the tips of the papillæ, rupture the egg-sacs, they are naturally unavoidably pressed into the layer of mucus that is secreted at this time by the other side of the ovarian tube.

When the eggs have become embedded in the mucous veil, this ribbon-like structure becomes detached from both sides of the flattened, tubelike ovary, and passes down the tube and out into the sea (Fig. 4). This process would be interesting to watch could we observe it, and some research worker may some day catch a *Lophius* out on its spawning grounds just before the eggs are laid and thus be able to watch the process. Another fish, *Pterophryne histrio*, a cousin of *Lophius*, has the same breeding methods but is much smaller and easier to study. The laying of these two ribbons of eggs probably takes some time on account of their length and the smallness of the passage.

The egg raft probably swells to its final length, width, and thickness only after coming out into the water. At this time it has a faint yellowish-white color with a purple fluorescence in certain angles of the light. It is possible that the slight yellowish opacity is due to the mucous material. Unfortunately no analysis or chemical study of the "veil" has ever been made.

As has been said, all the ripe eggs in the ovaries are discharged at this one time in the two ribbons. Some eggs, however, fail to become seated in the ribbon and others become detached shortly after laying. Such free eggs float to the surface and there develop. Each egg is not strictly round but slightly elongate. Its longer diameter is about 1.75 mm. and the other a little less. There are several fairly large oil droplets in it such as many pelagic fish eggs possess. A short time after development begins the larger of these several oil droplets coalesce forming one large drop with some very small ones next to it.

The number of eggs in a raft of course varies but has been rather carefully estimated at about an average of 1,000,000 in the veils from the usual sized fish. Fulton calculated the numbers in two veils as 1,345,848 and 1,312,587 respectively.

On the whole this veil has a tendency to float. The eggs, separated from the jelly, readily rise to the surface. The jelly material of the structure is slightly heavier than water and, alone, it will sink. The two together are *almost* balanced. The extent and thinness of the veil make it entirely subject to any current, however slight. As most bottoms of the sea are subject to some currents, the veils must be borne about by these, and as the fish is known to prefer a rather rough bottom, it seems probable that the veils must catch on various marine growths and projections and be more or less anchored most of the the time. Thus they would be held near the bottom until the young fish are freed. On the other hand, very slow currents will often carry the veils upward until they impinge on some bank or rock where the soft jelly is easily torn.

There are comparatively few records of the finding of these veils. On the Maine coast, however, the writer has found several and every fisherman and lobsterman has seen them Usually these rafts are not perfect, and often one finds only a part containing a few thousand eggs with the embryos nearly always in an advanced state of development (Fig. 5). Owing to this develop-

ment the color has become darker and the purple sheen stronger. It seems probable also that all these veils that float inshore do not liberate healthy and normal young fish and that these young fish do not live beyond a rather early larval life. Only those eggs that remain on the pelagic breeding bottom, floating around in suspension or caught lightly against some rough projecting object, have the best chance for maturing. There are some writers who believe that most veils normally float in suspension near the surface, but here again we must collect more well established facts than we already have in order to learn the truth.

One thing seems certain, a rather large proportion of mature eggs (let us assume 5 per cent) fail to become firmly embedded in the jelly layer but are nevertheless extruded. These eggs by virtue of their higher specific gravity must quickly come to the surface. Their occurrence would thus mark out the breeding areas of the adult fish more accurately than would the occurrence of the veils, provided only the very earliest stages were used, for at the surface the veils would be more widely scattered because of the stronger surface currents.

The method of fertilization of the eggs by the male is entirely unknown and can only be guessed at. As he has no intromittent organ as have the sharks and rays and bony fishes of several groups, we must assume that one or more males are present when the egg ribbon is laid, and that they eject a sufficient quantity of milt near enough to the ribbon to insure the fertilization of practically all the eggs, as is proved by their development. This method is much like that of our frogs and toads where the spermatozoa have to penetrate the jelly that surrounds the eggs.

LARVAL AND POST-LARVAL DEVELOPMENT

The exact time of development of the larva up to the hatching period has not been accurately determined and is not at present of major importance since we know the latter part of this period and can come rather close to an accurate estimate of it from comparison with the larval histories of other teleostean fishes. The end of the larval period proper comes when the young fish ruptures the egg membrane, but still it does not emerge from the jelly for a variable time after that. Also, according to the temperature of the water, the embryos will develop slower (in colder) or faster (in warmer water).

We can put this larval period proper at about 3–4 weeks (Fulton) without too great a probability of error, and the period during which the young fish remains in the jelly raft at 1–3 days (Fig. 5). It then comes out free in the water and swims about (Fig. 6) a post-larva. This post-larval period may be divided into two parts, during which the fish's growth and structure seem aimed at two entirely different and distinct purposes. The first is to fit it for an efficient and active pelagic life; the second is a series of gradual changes that result in fitting it for the lazy bottom life above described. The fishlet passes a considerable period in the first stage, longer than most fishes.

Without going into too much detail, we may say that the little fish's adaptation for the post-larval pelagic existence consists in three factors. His body, especially the head, grows narrower rather than flat, thus taking the form of a fish that is to move rapidly through the water. The second adaptive feature consists in the development of his fins into comparatively enormous surfaces that are to prevent him from

sinking when at rest or moving slowly, a "plane" form which is adopted by many young (and some adult) pelagic organisms (fishes, crabs, and worms) found near the surface of the sea.

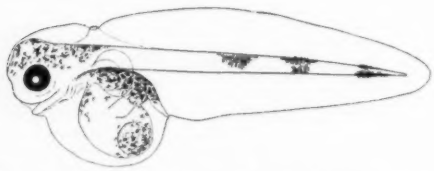


Fig. 6.—*Lophius piscatorius*. Newly hatched larva of 4.5 mm. After Å. V. Tåning

The third feature is a combination of reflexes and habits,—his swimming, which has been described by Stiasny as mostly performed by a fluttering motion of the great fins, and his erratic course in search of particles of food. He has no fishing rod or lure at this time, but actively darts about picking up first small organisms such as diatoms and later young and then adult copepods. His ventral fins move with a lively up and down motion while the large pectorals also vibrate strongly. A wide dorsal fin arises from his back and gives him stability in the water, and when he ceases all fin motion he appears to lie suspended although in reality he is sinking very slowly, since his specific gravity like that of most fishes is slightly greater than that of the water.

The distribution of the young post-larval stages is from the seaward shores out to and just over the edge of the continental slope. They are not found in the smaller bodies of water, hardly entering into the North Sea in Europe, and those that do probably not developing to maturity. On the American coast the post-larval stages are also found distinctly off-shore, to the extent of being most frequent near the edge of the continental shelf, although our prevailing southwest winds often bring them in nearer the coast.

Thus it is fairly easy to get the developmental stages of the fish during its life in the egg and also easy, with some care, to hatch these eggs out in the laboratory and keep the young fish for a few days. At first they get their nourishment from the yolk-sac which persists after hatching, but even at this time they begin to eat minute diatoms and other organic particles. Soon, however, the fish thus hatched in captivity cease to grow and die shortly after the yolk-sac has been absorbed.

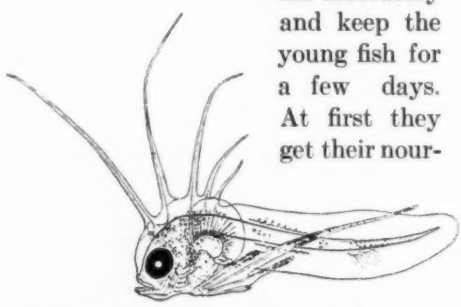


Fig. 7.—*Lophius piscatorius*. Post-larva of 11.5 mm. The first dorsal and the ventral fin rays are beginning to elongate. After Å. V. Tåning

This very clearly indicates that our only hope of tracing the history of this fish, from shortly after hatching to the time when he has become a settled "ground fish," will be in following up his post-larval life at sea and piecing together the various facts that we are able to secure by using the tow-net. This has been done in part by the workers already mentioned, especially Tåning, who has had access to some of the best material secured by the Danish oceanographic expeditions.

An important contribution to the solution of this problem has been to record the capture of the smallest adult specimens that have been taken. These specimens, although rare, are not so scarce as the post-larval stages. At a point off Lybster in British waters no less than thirty-six young anglers, ranging from five to eight inches in

length were taken in one haul of a dredge. These fishes, although settled bottom forms, give us no very exact limit to the end of the post-larval existence. Fulton gives a list of the smallest bottom captures and in this we find that the lower limit of bottom size appears to be about 50–60 millimeters. The transition from post-larval existence to bottom life is evidently gradual,

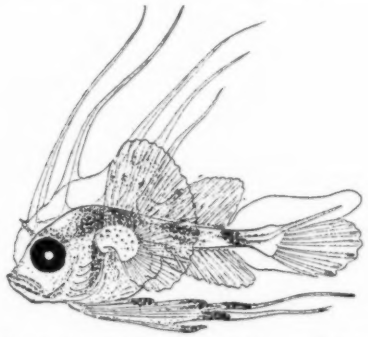


Fig. 8.—*Lophius piscatorius*. Post-larva of 16.5 mm. The caudal fin has appeared and the elongation of fin rays has continued. After Å. V. Tåning

more so than in a fish like *Astroscopus*. It may even vary greatly in different individuals and especially under different conditions of temperature and season, character of bottom, availability of food, etc.

Omitting, for the present, features due to varietal or specific differences, let us try to extract from the excellent works of Stiasny, Fulton, Lebour, Tåning, and others a general conception of this post-larval history.

The newly hatched larva (Fig. 6) is able to swim and has several days in which to learn to eat living organisms for food, being nourished meanwhile by the absorption of its yolk-sac. This yolk-sac, the large oil globule helping, tends to carry the baby fish up, and these stages are thus found in the u per strata of water, but not usually at the surface. Tåning speaks of them best found at 15-75 fathoms down. It appears that the youngest forms live higher up in the water, probably buoyed up by the yolk-sac. After this is partly or wholly absorbed, the young post-larva tends to live in deeper strata of water

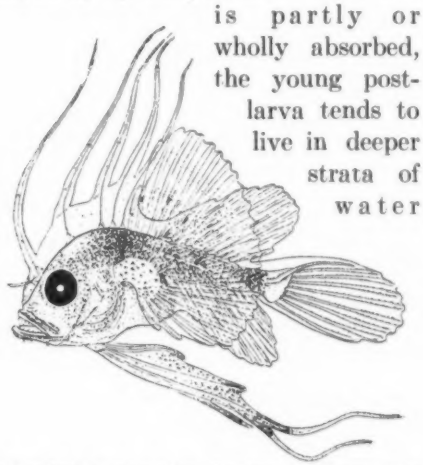


Fig. 9.—*Lophius piscatorius*. Post-larva of 26 mm. The enlarged surface of all fins is now apparent. The "fishing rod," which is first seen in preceding figure, now projects from the head. After Å. V. Tåning

but its level must have varying factors to determine it as it is not confined to well established limits.

It is at this time that the structures favorable to its free swimming open sea life begin to appear. An embryo of 11.5 millimeters in length shows this well (Fig 7). The dorsal fin rays, five in number, have grown up through the fin fold to great lengths, the ventral fin rays have elongated so that one of them reaches almost to the caudal extremity, while the pectoral fin has enlarged in lesser measure and the caudal fin has not yet appeared.

At 16.5 millimeters (Fig. 8) the anterior dorsal rays have continued to enlarge but not so greatly. The ventral fin has reached the caudal extremity and developed a web of some extent for support in the water. The second dorsal and anal fins have appeared, giving the body large vertical surfaces, and the caudal fin has appeared on the ventral side of the spine axis in eight rays and a complete web. The pectoral

has enlarged to a great plane that can be used in the vertical or the horizontal position or at any intermediate angle and it is plainly the principal propulsive organ at this stage.

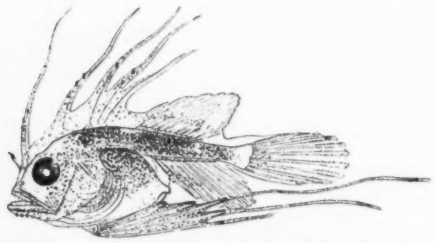


Fig. 10.—*Lophius piscatorius.* Post-larva of 32 mm. The pectoral fin has been removed in this specimen in order to show more clearly the other structures. This stage, in which the lure has begun to develop on the "fishing rod," is close to the maximum development for pelagic life. After Å. V. Tåning

At 26 millimeters the anterior dorsal rays have not gained in comparative length (Fig. 9), but the first dorsal ray, which was but a rudiment in the 16.5 millimeter stage, has pushed through and is beginning to elongate slightly. This ray is destined to become the "fishing rod" with its "lure" on the tip, but it now will remain backward in development during the whole post-larval stage and until after the fish has settled on the bottom at a much later period.

A considerably older stage is shown in Fig. 10 of an embryo of 32 millimeters. In this stage the maximum length of the ventral rays has been attained and is probably past. The first dorsal rays are stationary in length and are beginning to thicken. The pectoral, although it has been removed to show other fins, is still very large and may be said to have reached its maximum in extent of surface. In fact, we may say that at this age the fish has attained the height of his adaptation for the free pelagic life. Only the mere rudiments of any adaptation to his future bottom life have appeared in the presence of the beginning of his fishing rod and an indication of the lure, in a slight thickening of the dorsal rays with the appearance of dermal appendages, also in a slight comparative shortening and thickening of the body together with a greater development of the head in proportion to the trunk.

TRANSITION FROM POST-LARVAL TO ADULT FORM

In the next stage figured by Tåning (my No. 11), from a 46 millimeter specimen, we see marked features in regression from the post-larval characters and in development of the adult features. The first dorsal rays have shortened and thickened. The lure has

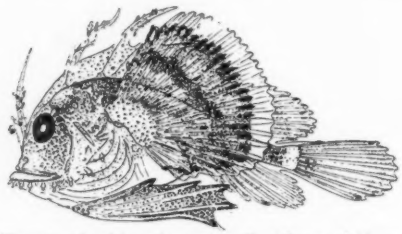


Fig. 11.—*Lophius piscatorius.* Post-larva of 46 mm. A pelagic stage in which the permanent features of the adult ground stage have begun to develop. The "fishing rod" or first dorsal ray has acquired its lure. After Å. V. Tåning

developed in form but remains small while the fishing rod remains short. The pectoral is still the large propulsive organ but the second dorsal, caudal, and anal fins, and the ventrals have comparatively decreased. It is evident that the fish has to work harder to keep itself up in the water and that the proportional weight of the body has increased considerably, especially in the head region.

Fig. 12, which was photographed from Tåning's largest post-larval specimen, evidently represents a stage in which the post-larva has acquired a form so much like the adult that it is ready to assume the bottom life. How gradual or how sudden this change of

habitat may be we have no means of telling. Probably it extends over several weeks or even months, the two-inch fish at first resting temporarily on the bottom and making shorter and shorter excursions into the waters above it. Probably the three-inch fish

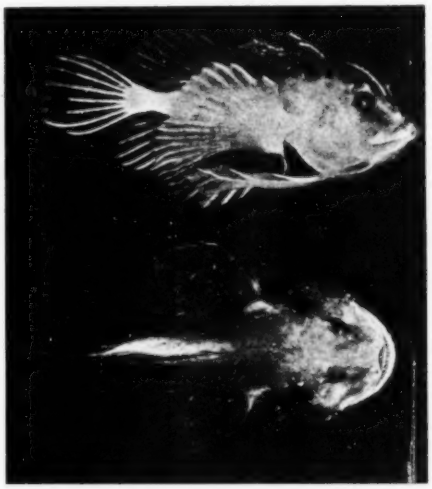


Fig. 12.—*Lophius piscatorius.* Photograph of top and side of a 60 mm. postlarva, the largest ever taken. This stage represents a fish in the process of changing from the pelagic to the ground life, as is shown by the widening and enlargement of the head and by the large size of the pectoral fins. After Å. V. Tåning

is pretty well established on the bottom. Many post-larval fish like this must be lost by drifting too far from their future habitat to be able to live. Most of them settle in deeper areas and only come inshore when well grown.

SOME INVERTEBRATE ENEMIES OF THE YOUNG *LOPHIUS*

Elsewhere we have considered some enemies of the adult *Lophius*, but the larval and post-larval young also have many enemies to escape if they are to grow up. Miss Lebour working at the Plymouth (England) laboratory has discovered and figured certain small invertebrates which preyed on the baby Lophii in her hatching jars, and which presumably feed on the fishlets in the open seas. The four figures now to be given are copied from her report.

In one of these jars containing little anglers, there were young forms of a ctenophore jelly fish with a blunt-lobed body. These were feeding on the abundant copepods and it was thought that they would not bother the little anglers. However, the young Bolinas (ctenophores) readily caught the little fishes as is shown in Fig. 13 The *Bolina* would encircle the actively moving *Lophius* with its blunt tentacles (a) and the struggling fish would be

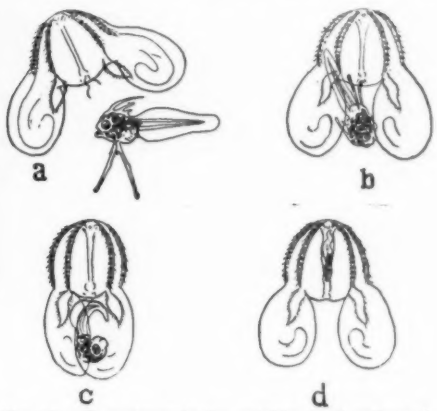


Fig. 13.—Four stages in the catching and eating of a *Lophius piscatorius* larva by a ctenophore in an aquarium at Plymouth, England. After Dr. Marie LeBour

completely enclosed by the tentacles and brought to the mouth (b and c). Thence it would be carried to the stomach and digested (d). Thus Bolinas from 4–30 mm. long would catch and devour anglers from 1–10 days old, the smaller ones taking in one fish, the larger ones sometimes two.

If the young angler escaped the tentacles of the ctenophore, it was likely to fall into the clutches of the *Phyllosoma* larval stage of the rock lobster (*Palinurus*), or as it is called in our southern waters the "salt-water crayfish." Figure 14 shows a *Phyllosoma* that has seized and is devouring a baby angler. These larvæ abound in the water of the open sea at Plymouth,

and must account for a great many little anglers. However, this is not the only crustacean enemy of the baby anglers. An active copepod called

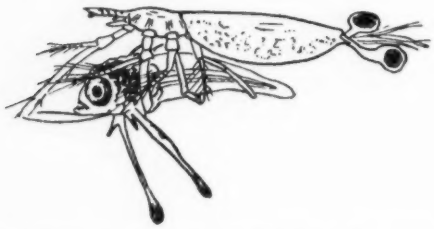


Fig. 14—Showing the manner in which a Phyllosoma larva seizes a larva of *Lophius piscatorius* to eat it. After Dr. Marie LeBour

Anomalocera was also found to seize and devour fishlets of about its own size in the hatching jar. These little anglers were still undergoing larval development, weak and encumbered with a yolk-sac (Fig. 15) poor swimmers and easily overtaken.

There was still another enemy which fed on the little fishes when they descended to the bottom of the jars, and which acted more as a scavenger than a real enemy. This was a small hydroid, *Clytia* by name, which was forming colonies on the floor of the jar. These small "beasties" (only about 3 mm. long "over all") stood with tentacles outspread and whenever a fishlet touched one this would activate others as is shown in Miss Lebour's spirited sketch (Fig. 16 herein), until as many as three hydroids were found fast to and devouring one baby fish.

In view of the facts set forth in the preceding paragraphs well may Miss Lebour speak of ". . . the vicissitudes to which the little fishes are subjected."

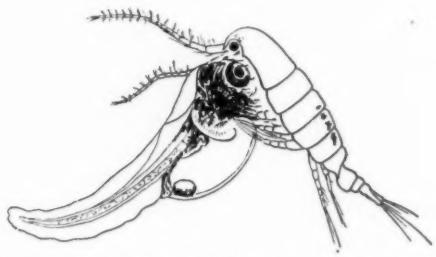


Fig. 15.—A *Lophius piscatorius* larva that has been caught and is being eaten by a copepod, *Anomalocera*. After Dr. Marie LeBour

And if they meet with these in the comparatively safe shelter of a hatching jar, what must they suffer in the open sea from other fishes, young and

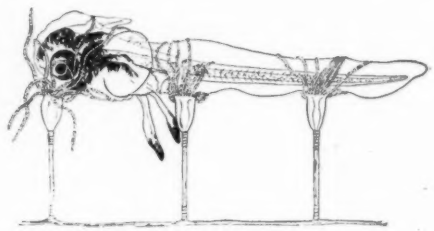


Fig. 16.—A larva of *Lophius piscatorius* that has been caught and is being eaten by three Campanularian hydroids. After Dr. Marie LeBour

old, from squids, crustacea of a hundred kinds, from worms—in a word from the millions of hungry carnivores which crowd the waters, all seeking what they may devour.

THE LOUSE-FISH (*PHTHEIRICHTHYS LINEATUS*) IN NATURAL COLOR (GREEN PHASE)

Reproduced by courtesy of Mr. W. K. Vanderbilt

Painted by William E. Belanske while on the "Ara" expedition of 1926 to the Bahamas and Galápagos Islands

The Louse-fish (*Phtheirichthys lineatus*)

WITH AN ILLUSTRATION IN COLOR

By E. W. GUDGER
Biographer and Associate in Ichthyology, American Museum

EARLY in 1926 (January 20–April 9), Commodore W. K. Vanderbilt led an expedition to the Galápagos Islands by way of the Bahamas and the Panama Canal. This was intended not merely as a pleasure cruise, but had the more serious purpose of collecting natural history specimens—particularly fishes—for his private museum at Northport, Long Island. In order that accurate color sketches from life might be made of the fishes, there went as a member of the "Ara" expedition, Mr. Wm. E. Belanske, a skilled artist, who has had much experience in making color drawings of marine animals for and under the critical direction of various members of the scientific staff of the American Museum.

Mr. Vanderbilt, who is a trustee of the American Museum, has published privately an interesting account of his expedition and in this has reproduced in a style worthy of their excellence Mr. Belanske's beautiful paintings of twenty-seven fishes. The originals of these figures have been presented to the department of ichthyology of the American Museum, and (properly mounted) are now on display in our new hall of fishes. Inspection of these will justify the statement that no more lifelike representations of fishes have ever been made. Ichthyologists owe Mr. Vanderbilt a debt of gratitude for these entirely adequate color figures of the rare fishes taken on this expedition, at least one of which is new to science.

Plate XXIV of the work referred to shows the rare and exceedingly interesting little sucker-fish known as *Phtheirichthys lineatus*.[1] This is the first and only known portrayal in life colors of this member of the Echeneididæ, and thanks to Mr. Vanderbilt's kind permission to use the plate, I am able to reproduce the figure in this article and make it available for ichthyologists. The fish itself had already been briefly described by me in a paper dealing with other small Echeneids of this and other genera.[2]

This rare specimen (which lies before me as I write) was taken from a barracuda caught with hook and line off Hogsty Island in the Bahamas on February 13, 1926. It was at once put alive and unhurt into an aquarium of fresh sea water, and then and there was made the painting of which the plate is an exact reproduction. Fish and figure are described on pages 145–146 of Mr. Vanderbilt's book. This fish was of a uniform green color, practically black-green on the head and pelvic fins, on the basal parts of the pectorals and of the dorsal and anal fins, and on the anterior half of the caudal fin and the whole of its median lappet. Along the mid-lateral region of the fish (over the lateral line) runs a light green stripe, above and below this are darker green bands and, finally, along the roots of the dorsal and anal fins are likewise light green lines. The pectorals, the high anterior parts of dorsal and anal fins, and the upper and lower lobes of

[1]Vanderbilt, W. K. *To Galápagos on the Ara* [New York, 1927, privately printed] pp. 14, 145–146, pl. xxiv.

[2]Gudger, E. W. "A Study of the Smallest Shark-suckers (Echeneididæ) on Record," etc. *American Museum Novitates*, 1926, No. 234, pp. 10–13; 23–24.

the caudal are in color a light green merging into white. Further consideration of the color of this particular fish will be taken up later in connection with that of other specimens of this species and of other members of the family.

This small sucker-fish is 64 mm. long "over all," 51 mm. in standard length, and has a caudal fin 13 mm. long to the end of the central lappet. With one possible exception (to be referred to later) it is the smallest known specimen of the genus. The sucking disk has ten lamellæ only—the smallest number found in any living member of the family. There is, however, a fossil form (*Echeneis glaronensis*) from Switzerland with the anterior portion of the disk gone, which has 5 lamellæ remaining, and which (as I have elsewhere shown) could not have had more than 2 or 3 additional lamellæ—or from 7 to 8 in all.

The first known specimen of our little sucker-fish was about 5 inches long (125 mm.) and was taken from a turtle in the central tropical Pacific ocean. Archibald Menzies,[1] its describer, thinking it to be an ordinary striped echeneid, designated it as *Echeneis lineata* in 1791. For comparison's sake, his figure is reproduced herewith as No. 1. His specimen was presumably about one half to one third grown.

The present specimen was taken from a barracuda, and the only other recorded American specimens were also taken from barracudas. Thus Poey,[2] the Cuban ichthyologist, says of the sucker-fish which he calls *Echeneis sphyraenarum*, that "This little *Echeneis* has thus far been found only on the *Sphyraena picuda*. It hides itself between the gills and escapes thence when the large fish is taken." Hence Poey gives it the common name "*Pega de las Picudas.*" His specimen, which had been much shrunken through long immersion in alcohol, was 75 mm. (about 3 in.) long, and had 10 lamellæ in its disk. The tail fin had a central lobe about one and one half times the length of the caudal proper. This lobe he found on all his specimens, and hence he thought it a distinctive character. The color of the specimen described was "a very dark blue verging on to black."

My personal knowledge of this species is confined to one possible specimen. This was taken from a barracuda caught by trolling at the Tortugas, Florida, late in the afternoon of July 4, 1914. It was put in an aquarium of running sea water and during the night escaped down the drain pipe or was carried away by a cat, hence it

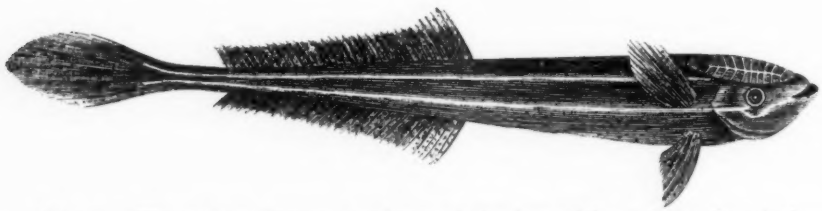


Fig. 1.—The earliest known specimen of the louse-fish—"about five inches long"—taken from a marine turtle in the tropical Pacific ocean. Note the spatulate or plumose tail, indicating that this fishlet is about half-grown. After Menzies, 1791

[1]Menzies, Archibald, "Descriptions of Three New Animals Taken in the Pacific Ocean." *Transactions Linnæan Society London*, 1791, Vol. 1, p. 187; pl. xv, fig. 1.

[2]Poey, Felipe. *Memorias Sobre la Historia Natural de Cuba.* Habana, 1856, Vol. II, pp. 252–255.

was not positively identified. But, from its small size (about 4 in.), its plumose tail, and its capture on a barracuda, it is believed to have been *Phtheirichthys*.

That this Echeneid is found on the barracuda is undoubted, but Poey's contention that it is found only on this fish is not tenable, inasmuch as Menzies' specimen came from a turtle.

of the fin proper. This specimen, then, presuming that it was drawn *life size*, was 3 mm. shorter than Mr. Vanderbilt's. Günther's figure is here reproduced as No. 2.

It is noticeable that up to this point all the authorities quoted call our fish *Echeneis lineata*. Now Linnæus long ago applied the generic name *Echeneis* to sucking-fishes having 20–28 lamellæ

Fig. 2—A post-larval louse-fish showing the prolonged central lappet of the caudal fin. Presumably a life-size figure (85 mm. or 3.4 inches in total length) of a specimen in the British Museum. After Günther, 1876

The opinion is generally held that certain species of sucker-fishes are found only (or at any rate mainly) on certain host fishes. This has not been proved, but it is a matter of no small interest and worthy of considerable study.

Günther,[1] in working over the fishes collected in the South Seas by Andrew Garrett found a small *E. lineata*. This he figures, presumably in life size though he gives no scale. The fish as drawn is 61 mm. (2.5 in.) in standard length and 85 mm. (3.4 in.) over all. The caudal is 24 mm. in total length, of which the central lappet projects 13 mm. (0.5 in.) beyond the hinder edge

in the disk, so plainly our fish with 9–11 lamellæ cannot belong to this genus. As a matter of fact, that keenest of all American ichthyologists, Dr. Theodore Gill,[2] had in 1862 given it the name which it now bears—*Phtheirichthys lineatus*. This name became fixed in the literature by the publication in 1882 of Jordan & Gilbert's *Synopsis of the Fishes of North America*.

The name *Phtheirichthys lineatus* literally translated means the striped louse-fish. The question of stripes will be discussed later, but just here it may be well to call attention to a short article which I published in 1916,

[1]Günther, A. C. L. "Andrew Garrett's Fische der Südsee", Bd. II. *Journal Museum Godeffroy*, 1876, Bd. IV, pp. 156–157, pl. xcvii, fig. 1.

[2]Gill, Theodore N. "Remarks on the Relations of the Genera and other Groups of Cuban Fishes." *Proceedings Academy Natural Sciences Philadelphia*, 1862, Vol. 14, p. 235.

which has some bearing on the matter of the name louse-fish.[1] In this article, Aristotle is quoted concerning a sucking-fish that accompanied dolphins found in the waters between Cyrene and Egypt, and which was called the "dolphin's louse." Further, Hasselquist (1762) and later Forskål (1775) were quoted that in their time sucking-fishes found on sharks around Alexandria and at Djidda on the Red Sea were called respectively *Chamel el Ferrhun*, "the louse of the terrible one" (i. e. shark); and *Kamel el Kersh*, "the louse of the fish of prey" (a *Carcharias* shark according to Forskål). Here, then, we have the name louse-fish given to Echeneid fishes in classical antiquity and as recently as 150 years ago in near-eastern waters. Gill's giving the name *Phtheirichthys* (louse-fish) in 1862 to our small Echeneid has good warrant, then, in times as far back as Aristotle.

We now come to the matter of the color of this fish, and here, as in all cases of consideration of the color of tropical fishes, we are treading on uncertain ground. Many if not most tropical fishes have from 3 to 6 color phases, and when such a fish is caught one cannot describe it by its color unless one knows in what phase it is. To study these phases one must have had long experience and accurate observations of the wild fishes on the reefs or of tamer ones in the artificial conditions of captivity. Only a few months ago, at the New York Aquarium, I saw three specimens of the common shark-sucker, *Echeneis naucrates*, resting side by side on the bottom of a tank. One was light ash color without trace of stripes, one almost black with no stripes, and the third with the normal longitudinal stripes—a central black stripe from eye to caudal, above and below this white stripes with black regions above and below these.

Ichthyologists are exceedingly fortunate in having this color drawing of Mr. Vanderbilt's specimen of *Phtheirichthys*. That the fish was in the green color phase is beyond doubt—Mr. Belanske's painting must be taken at its face value. As to other specimens of this species, the facts are as follows. My living specimen of a presumed *Phtheirichthys* was black all over save for white on the head about the eyes and on the outer tips of the caudal fin. Poey (1856) described his specimen as "a very dark blue verging on to black."

That the common shark-sucker (*Echeneis naucrates*) has different color phases, I have noted above. That it may have other colors than those supposed to be normal will now be shown. First let Temminck and Schlegel be quoted that a specimen taken in the bay of Nagasaki, Japan, was grayish blue (lead color) with irregularly shaped and placed lighter blotches all over the body; the back (in front of the dorsal), the paired fins, the caudal, and the high front parts of dorsal and anal were a smoky black. Their colored figure shows the most unusual markings of any Echeneid known to me.

Furthermore, on July 8, 1914, I took from a nurse shark at Tortugas an *Echeneis naucrates* having much the coloration shown in the plate of *Phtheirichthys*. Looked at from above, the body was dark green, almost black, edged with a white line below on each side. Viewed from below, one found the same dark slate-green edged with white. Furthermore, Poey (1856) described a sucking-fish under the name *Echeneis metallica* (=*E. naucrates*). Of its coloration, he says that: "It is a dark green, gleaming or

[1]Gudger, E. W. "Aristotle's Echeneis not a Sucking-fish." *Science*, 1916, Vol. 44, pp. 316–318.

metallic; paler on the throat and under the head; having a band of darker green starting at the edge of the opercle, passing the eye and terminating at the maxillary. . . . This very rare fish was taken near the *Sagua la grande*, an old channel in Bahama." I have been unable to identify this region, but apparently it was in the Bahamas, whence our present-day specimen comes. It certainly is significant that it had much the same coloration as ours taken in this same general region seventy-five years later.

Here, then, we have, from two different specimens of another genus of sucker-fishes, confirmation of the accuracy of the coloration of the specimen shown in the plate. One of these specimens comes from the same general locality (Bahamas) and the other from the not distant Tortugas. When I studied and described my fish, I thought that I had chanced on an entirely new and unheard of color for an *Echeneis*.

All other specimens of *Phtheirichthys* studied have been preserved ones. Tanaka's (1913) Japanese specimen from Misaki, Sagami Bay, (212 mm. in total length) was dark brown in general color with two pale longitudinal lines separated by a brown band running along the lateral line as shown in his figure. Franz's (1910) specimen from the same locality after long immersion in preservative is described as having a practically identical coloring.

Günther's preserved specimen from the South Seas (1876) is described as having light areas above and below separated by a mid-lateral brown band, as shown in his plate (my Fig. 2). All of Lütken's specimens after long sojourn in alcohol had the dark laterally placed band separating lighter regions. Poey's (1856) preserved and much shrunken fish was "clear blue above, verging on to black," and earliest of all, Menzies' (1791) preserved fish (the type specimen) was brown all over save for two longitudinal white bands from eye to tail. (See my Fig. 1.) Furthermore, the brown areas were dotted all over with darker spots.

Mr. Vanderbilt's specimen, which has now been in preservative for fifteen months, today shows the following coloration—a narrow dark band from eye along lateral line to caudal fin, above and below this lighter (brown) areas dotted all over with minute darker spots. Thus the color of this fish after long action of the preserving fluids is practically that of all others which have had similar treatment.

As has been shown in my 1926 paper elsewhere referred to, the elongated central portion or lappet of the caudal fin in the Echeneis group of the sucker-fishes (*Echeneis* and *Phtheirichthys*) is a larval, or better, postlarval character. As figures of older specimens of the latter fish by Menzies, by Tanaka, and by Günther show, the caudal fin in specimens 125 mm. (5 in.), 212 mm. (8.4 in.), and 235 mm. (9.4 in.) long, has a rounded spatulate hinder edge. Unfortunately, the American Museum does not contain specimens of the louse-fish for comparison. How large *Phtheririchthys* grows is not known, but Günther remarks that the largest in the British Museum Collection was 16 inches long.

Fig. 1.—A Tahitian outrigger canoe similar to those used by the native fishermen of Tongareva and Atiu

Fishing for the Oilfish

NATIVE METHODS OF DEEP-SEA FISHING FOR *RUVETTUS PRETIOSUS* AT ATIU, HERVEY GROUP, AND ELSEWHERE IN THE SOUTH SEAS

By CHARLES B. NORDHOFF
Papeete, Tahiti, French Oceania

IN the hope that what little I have picked up about fishing for the oilfish, *Ruvettus*, may be of interest to others, it is a pleasure to bring together and to record in NATURAL HISTORY some of my notes on the hook used and the method of taking this fish. What I have to say is the result of my own observations or of conversations with native informants for whose reliability I can vouch.

It is known that *Ruvettus* is caught in Japanese waters and in the Banda Sea, and there is some reason for believing that the peculiar technique of this fishing throughout the South Seas reached there by way of Micronesia. Possibly it came eastward through the Carolines to the Gilberts, thence south to the Ellice Group, next southeastward to Samoa, to Tonga, to the Cook Islands, and the Austral Group. Furthermore, this peculiar method of fishing is practiced in islands or groups of islands lying roughly between the meridians of 150° and 170° west longitude. In the Hawaiian Islands on the north, there was formerly fishing for a fish called *walu*, (now known to be *Ruvettus*) with a hook very like the peculiar one presently to be described. Farther south the same fish is known as the *palu*, and today its fishing plays an important part in the lives of the native inhabitants of Puka Puka (Danger Island), of Penrhyn (Tongareva), Rakahanga (Rierson Island), Manihiki (Humphrey Island), of Atiu and Mangaia in the Herveys, and of Rimatara and Rurutu in the Australs. It is well known that Rurutu and Atiu men introduced this fishing in Tahiti not many years ago, and an old Atiu man, who was a sailor among the Paumotu atolls in the days when some of them were still quite primitive, tells

me that the natives of that group knew nothing of *Ruvettus* in the early days.

At Penrhyn Island (Tongareva), *Ruvettus* is called *vena*, a variation of its Polynesian name *uravena* or *kuravena*, and there a peculiar method of sinking the hook is used. The fisherman cuts half a dozen light sticks of wood, each a couple of feet long and having a short fork at one end. To the other end he attaches a lump of coral, made fast with a bit of pandanus fiber. The fork at the upper end is then laid over the bend of the wooden hook, which is thus carried down to the bottom, where the weight of line, hook, and bait permits a speedy disengagement. The forked stick and stone are called *ru*, and a new *ru* is required each time the line is let down. The point of the hook is called *mata*. This fishing is done in three hundred fathoms, and on dark nights. Hence the week of the new moon is the best time.

In Manihiki and Rakahanga (two atolls less than thirty miles apart and inhabited by the same people, who travel back and forth and are great *Ruvettus* fishermen), *Ruvettus* is called *palu*. This is a survival south of Penrhyn, of the northern name. The whole assembly of hook and point is called *kaupalu*, and the point *matika*. The sinker is known as *maini*, and the method of attachment is the same as that used in Atiu.

In Atiu, one of the southern Cook Group, *Ruvettus* is of great economic importance to the people, and the younger men fish for it on every calm, dark night. I have had in my household for years an old Atiu man, with whom I have had many a long yarn about *Ruvettus* fishing, so I shall go into a little more detail in the case of that island, where the methods in use are typical of southeastern Polynesia. The fish is called *kuravena*, the wooden part of the hook (made of casuarina wood) is known as *toko*, the point *matamata*. The sinker is perhaps worthy of description. The fisherman selects a few indurated coral or volcanic stones of suitable shape, and surprisingly large to my eyes. (Some I once weighed, out of curiosity, ran from eight to ten pounds each). He then peels off some flat strips of wild hibiscus bark, half an inch wide and more than a yard long. This bark is usually known as *more*, but the strips are called *atari*. When the hook is baited and ready to be lowered into the sea, the fisherman takes a strip of bark, makes a hard knot in one end, and splits the strip just above the knot. The other end is then passed through the split, making a noose which is pulled tight about the stone. The upper end of the bark is then given a turn about the shank of the *toko*, just above the crotch, with the end passing *under* the part attached to the stone. This hitch will hold as long as the line is taut, but lets go the moment the tension is relaxed.

The baits generally used are flying fish (*Cypselurus simus*), or *ature* (*Trachurops crumenopthalmus*), though I

Fig. 2.—*Ruvettus pretiosus*, the oilfish—a mounted skin in the American Museum. From a four-foot specimen, weighing 24½ pounds, taken at Bermuda, December 19, 1924

fancy any small fish will do. I know one old fisherman who swears by chicken—raw, of course! The small fish, 6 or 7 inches long, are split in two lengthwise, and the backbones thrown away. It takes four such fillets, or two fish, to make one bait. The bait (known in Atiu as *araainu* or *mainu*) is lashed with thread or fine fiber to the *toko*, one piece at a time, and just under the point, which is left exposed. One piece is lashed to the inner side, one to the outer, and one each on the front and back sides, making what might be inelegantly called a "gob"—no doubt a tempting one to *Ruvettus*. My sketch will explain this clearly.

Now suppose it is a calm night in Atiu, with no moon, and, above all, no current. The fisherman goes out alone in his sixteen- or eighteen-foot out-rigger canoe. He carries no lantern or torch for this work, only his line, sinkers, hook (and a spare one perhaps), bait, fish-club of ironwood, and thread for lashing on bait. The line, more than 2500 feet of it, is done up very neatly in what he calls *potaro*—a ball which allows the line to run out from the inside. When all is ready, he drags his canoe over the fringing-reef, waits for a favorable opportunity, and pushes out through the breakers.

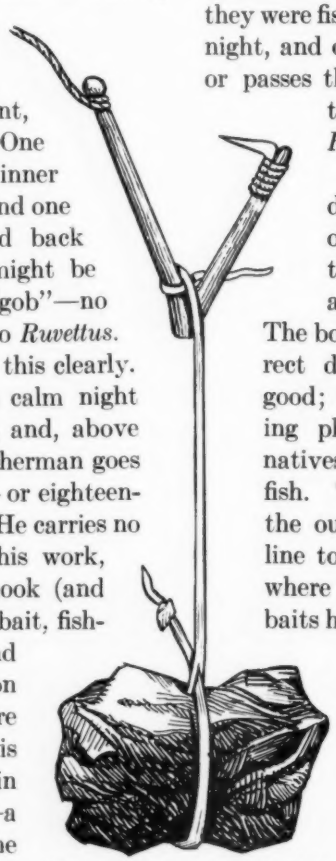


Fig. 3.—A hook from Atiu in which the sinker is held by a slip knot. When the weight rests on the bottom, the thong is automatically released. The barb itself is made of a right-angled fork of hard wood. From a sketch by the author

There is a significance in the fact that Manihiki, Rakahanga, Atiu, Mangaia, Rimatara, and Rurutu are all islands where one must push off and land in the breakers, and that, except for the two first mentioned, they are islands without lagoons. On islands with fine lagoons and passes through the reefs, I fancy the people ran more to net-fishing inside, and bonito-fishing outside, as they were always sure of getting ashore without having to brave swells which might have risen while they were fishing. The sea is calmest at night, and on islands without lagoons or passes the people would naturally turn to night-fishing for *Ruvettus*, etc.

The fisherman now paddles to a place some distance off the reef, where he knows the bottom may be reached at say four hundred fathoms. The bottom anywhere at the correct depth seems to be equally good; there are no particular fishing places (or "holes," as the natives say) in the case of this fish. The fisherman first fastens the outer end of his big ball of line to the outrigger-pole (*kiato*) where it crosses the gunwales; he baits his hook, attaches the sinker, and allows the line to run out through the fingers of his right hand until he feels the sinker strike bottom. A little more slack, and a tentative slight pull tells him that the sinker is free. All is now ready. If there is a slight current or a breath of air he takes up his paddle, holding it low down with his left hand while the haft is braced under his left shoulder, and paddles very gently with this hand, just enough to keep the line vertical. This kind of paddling is called *tamau*.

If he has no strikes at this depth, he

takes the line at water level and with a sharp graceful gesture raises it above his head, making the movement *twice*, while his left hand takes in the slack. This raises the hook about two yards. If nothing then strikes, he raises the hook three times, and waits a little. After that he raises it four times, and so on up to six.

At whatever level he catches his first fish, he continues to fish the rest of the night. When *Ruvettus* strikes, he strikes hard, and makes four rushes so fierce that line must be paid out, before he gives up. (My old man insists on *four* rushes. Since the fisher has his ritual of 2, 3, 4, 5, 6 heaves of the line to find the feeding level, I suppose he fancies the fish has his ritual number of runs).

In addition to *Ruvettus*, the Atiu men catch with the same hook and at the same depths four other kinds of fishes. These they call *manga*, identified as *Promethichthys prometheus*, a not distant relative of *Ruvettus; hapuka*, the deep-sea grouper known as *Epinephelus quernus; utu*, ichthyologically designated *Bowersia violescens*, and *paru*, whose scientific name is *Etelis courus*. Note that the northern name of *Ruvettus* (*paru* — pronounced *palu*) is here applied to another fish caught on the same tackle.

Ruvettus undoubtedly grows to an immense size off Atiu and Mangaia; my man Monday says he has occasionally caught them so large that he had to make them fast with a bit of line and tow them ashore. The head of one was given to us, and I estimated the whole fish at 200 pounds. Monday declared that he had caught many twice this size. When a fish is hooked, the man lays the paddle in the canoe, and uses his left hand to arrange the line at his feet while the fish is brought up with the right hand. It takes a young and strong man to pull up a big fish from a depth of nearly half a mile, and do it several times in a night. It is a soaking-wet, back-breaking job, and I do not wonder that *Ruvettus*-fishing has never become popular in the Society Group. If the *Ruvettus* is small, the fisherman seizes him by the gills and breaks his back over the gunwale before taking him aboard. If larger, he is seized and then clubbed to death; and if a giant, he is made fast to the boat, clubbed, and towed ashore. His teeth are not considered dangerous. Strange to say, the release from the great pressures at which he lives seems not to affect him, as in the case of cer-

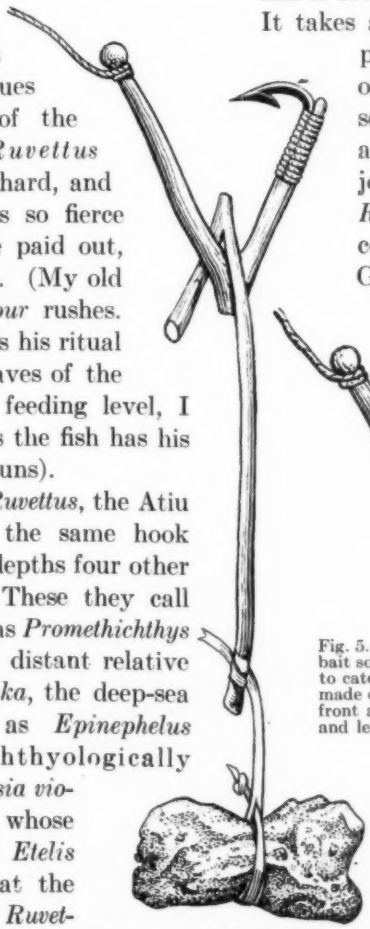


Fig. 4.—An oilfish hook from Tongareva showing the method of attaching the sinker, which is displaced when the apparatus strikes the bottom. The barb is made of the point of a European steel hook, bent to the proper angle and lashed to the top of the barb leg. From a sketch by the author

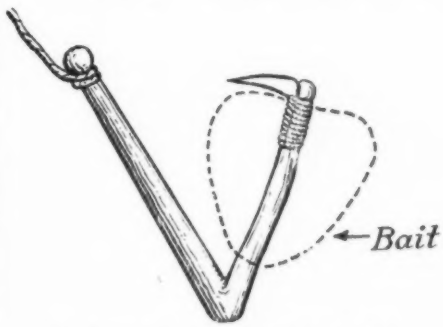


Fig. 5.—A wooden *Ruvettus* hook with the bait so lashed on as to leave the barb free to catch in the gills of a fish. The bait is made of four fillets of fish, one tied on in front and one behind, and two others right and left as described on page 42. From a sketch by the author

tain other deep-sea fish. This may be due in part to his readjustment to the decrease in pressure during his slow ascent to the surface. The lines are so long, and require so much time to pull up, that although they are valuable

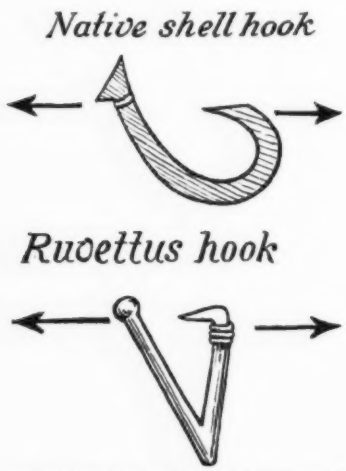


Fig. 6.—Sketches showing how a fisherman and a fish, pulling in opposite directions but in the same straight line, cause the native shell hook or the *Ruvettus* hook to become imbedded in a fish's mouth. From sketches by the author

property in native eyes, they are often abandoned, with or without a hooked fish, when the fisherman is caught in a sudden squall and has to make for shore.

As for the hook, the *toko* or hook proper is made of casuarina (iron wood), as I said. The point was formerly made of hardwood, bone, or pearl shell; today a large European hook is often used as a *matamata* (or barb), the bend opened to almost a right angle and the shank lashed to the *toko*. Another favorite *matamata* is made from the heavy wire handle of a kerosene-tin, bent and filed to a point. I never heard of a one-piece hook. They stick to the *toko*, I think, because sufficient bait could not be tied to a white man's hook, and what is more, I fancy that the native outfit will hook a larger percentage of strikes—a most desirable feature with 400 fathoms of line to pull in before rebaiting. In my opinion, the Polynesian incurved hook, of which our *Ruvettus* tackle is but one example, is mechanically superior to hooks of our kind, for when the fish strikes and begins to pull, the line and the point of the hook fall into alignment, tending to imbed the hook deeper and deeper in the fish's mouth, as is shown in the subjoined sketches.

As for lines, the old native hand-made line was superior in strength and lasting quality to anything that can be bought here in Tahiti today. I have one such line made by an old man who rolled it on his thigh, and in strength and regularity of "lay" it verifies all that Cook said in his remarks on Tahitian fishing-lines.

Ruvettus is found off practically all the South Sea islands—atoll and volcanic alike—where the requisite depth is reached. The atoll-dweller, where the reefs fall off abruptly to great depths, will find such depths a few hundred yards from shore. However, in the case of certain mountainous (volcanic) islands where the underwater slopes are more gradual, the fisherman has to go much farther out, possibly miles, before he finds the requisite depth. Here of course he is in greater danger from squalls, especially if he has caught a *Ruvettus* so large that it has to be towed ashore. Hence it is clear that with other edible fishes closer at hand and in abundance off high islands, *Ruvettus*-fishing will not be so favored as on coral atolls.

Natives say that *Ruvettus* should be cooked in the ground-oven on two or three successive days before it is eaten, and that a liberal sprinkling of lime juice improves the flavor and tends to nullify the ill effects of eating too much of this fish. And one is warned

not to suck the bones. The flesh is white, with a faint yellowish tinge probably due to the oil; is tender, flaky, and of fine flavor. It is particularly welcome in the tropics, where the flesh of practically all the surface-dwelling fish is dry. When the fish is boiled, a considerable amount of oil rises to the surface of the water. The celebrated effects of eating *Ruvettus* are somewhat exaggerated, but the fish is so good that one is likely to eat too much of it, when of course the purgative consequences are bound to be felt.

EDITORIAL NOTE

Our chief authority on *Ruvettus*-fishing is Louis Becke, whose books on the South Seas are based on years of experience as traveler and trader throughout the whole equatorial Pacific. Becke's first contribution is found in the late E. R. Waite's article on the fishes of Funafuti atoll, Ellice Group (*Memoirs Australian Museum*, 1897, Vol. 3, pp. 199–201). Here he describes the wooden hook, the line of 4- or 6-plait coconut fiber, and the stone sinker of from 4 to 6 pounds. The fishing is done on calm, dark nights, with a flying fish bait, at depths of from 150 to 200 fathoms, and in the strictest silence. In the same series of papers Charles Hedley ("The Ethnology of Funafuti," *Memoirs Australian Museum*, 1897, Vol. 3, pp. 272–276. figs.) describes the hook and its distribution at some length, and quotes a Mr. Jack O'Brien of Funafuti as to the actual manner of hooking the fish.

> ". . . the bait was a whole fish split and laid scales to scales on either side of the barb. In bolting this, the *palu*, whose jaws are very thin and pliable, gets the barb caught behind the angle of the jaw. Sometimes when the fish bites, the line is so jerked as to bang its head with the flat stone used as a sinker."

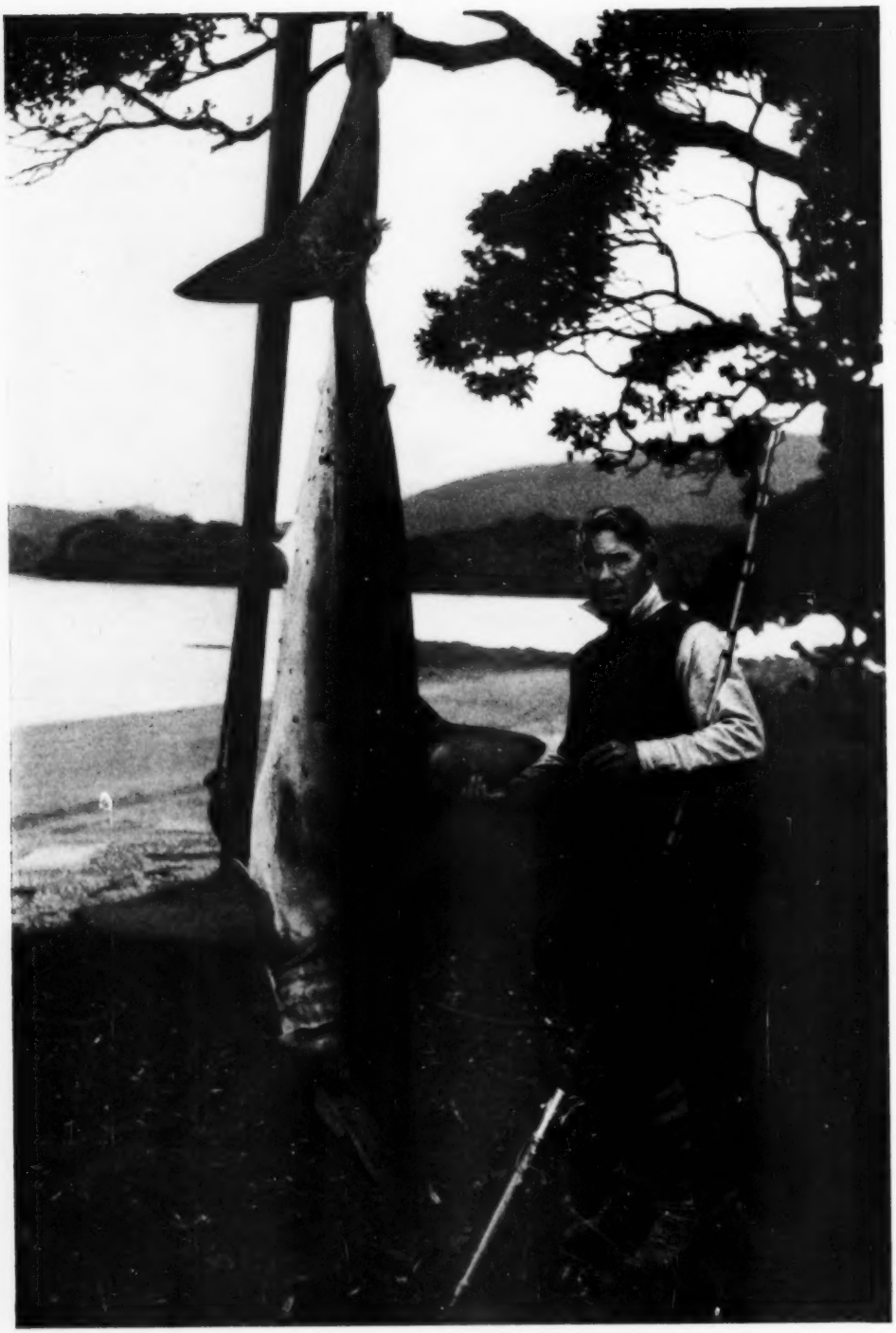
Stirred by these two articles, Augustin Krämer, published an article "Der Purgierfisch der Gilbertinseln," (*Globus*, 1901, Vol. 79, pp. 181–183. 3 figs.). He gives little new information, merely emphasizing that it is taken in deep water (about 300 m.) at the time of the new moon, on the typical large wooden hook. Krämer's article has largely to do with the purgative action of the oil, a subject on which all the available data has been brought together by E. W. Gudger—("A New Purgative, the Oil of the Castor Oil Fish, Ruvettus." *Boston Medical and Surgical Journal*, 1925, Vol. 192, pp. 107–111. fig.).

However, up to the time of publication of Mr. Nordhoff's article, the best and most complete account of fishing for *Ruvettus* is found in Becke's *By Rock and Pool on an Austral Shore*, (London, 1901, pp. 148–158), where accounts are given of this fishing as carried on at Nanomango, Ellice Group, and elsewhere. Becke declares that the night must be moonless and windless; that the large wooden hook, attached to a 4- to 8-strand coconut cinnet line, is baited as described by Mr. Nordhoff, that it is sunk to a depth of one hundred or more fathoms by a 3- or 4-pound coral stone sinker tied to the hook by a thin piece of bark readily broken when *Ruvettus* bites and hence left behind. Four men man the canoe and lower lines, one, however, paddling with one hand to keep the canoe from drifting—all in the utmost silence.

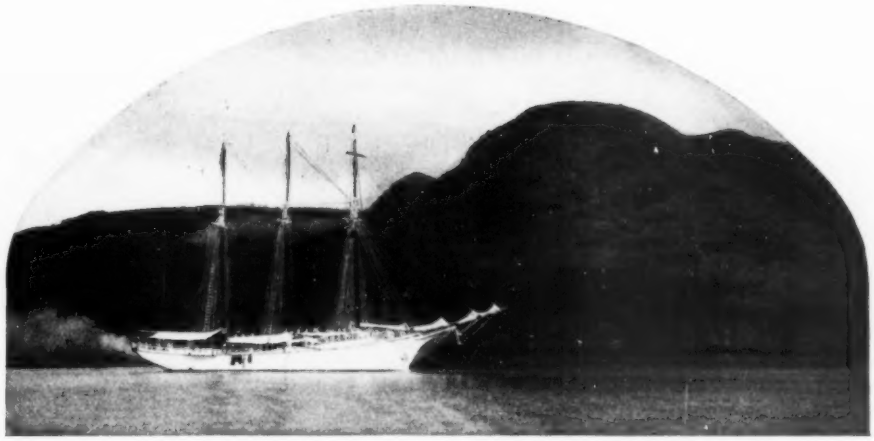
When hooked, the *palu* offers considerable resistance, but soon gives in and, except for the hauling in of his weight and that of five hundred or six hundred feet of line, is easily landed, if not caught and bitten in half by a hungry shark. The longest fish seen by Becke was 6 feet 10 inches over all; another "heavy-set" specimen had a girth of 40 inches, while his heaviest fish weighed 200 pounds.

From this it will be seen that Mr. Nordhoff's article, written twenty-five years after Becke's and Krämer's accounts, absolutely corroborates these men in every essential point. Mr. Nordhoff has made a valuable contribution to our knowledge of *Ruvettus*-fishing in the South Seas.

For complete data on the structure, variations, and distribution of the *Ruvettus* hook, the interested reader is referred to a monograph by E. W. Gudger, "Wooden Hooks Used for Catching Sharks and *Ruvettus* in the South Seas," etc. *Anthropological Papers*, American Museum Natural History, 1927, Vol. 28, pp. 201–348. 92 text-figs.



ZANE GREY AND HIS *MAKO* WHICH WEIGHED 278 POUNDS



The "Fisherman," Mr. Grey's yacht, off Whangaroa, New Zealand

Big Game Fishing in New Zealand Seas

By ZANE GREY
Patron of the American Museum

MY first fishing trip to New Zealand (1926) was in the nature of a pioneer expedition. The game was new there, and methods and tackle crude in the extreme. We anticipated criticism and opposition, and we certainly got it in plenty. The English anglers were slow even to consider American tackle and methods, let alone to adopt them.

The results of this trip, however, justified our venture and rewarded us beyond measure, and we had the satisfaction of winning a number of New Zealand anglers to our methods. We secured five world records, two of which were phenomenal. Here follows a partial summary of our catch; and the large number we think is justified owing to the desire of the New Zealand Government that we catch and identify and photograph fish, to attract the attention of the scientific and angling world to these new waters.

SOME RECORDS OF THE 1926 EXPEDITION

Captain Mitchell took two black marlin (*Makaira marlina*) of 685 and 976 pounds (the latter the world's record); 21 striped marlin (*Marlina mitsukurii*) ranging from 192 to 350 pounds and averaging 259½ pounds; 3 yellowtail (*Seriola dorsalis*) of 70, 75, and 80 pounds, averaging 75 pounds; and 6 *mako* (*Isurus* sp.) varying from 180 pounds (two specimens) to 299 and averaging 236 pounds.

I took, among other fishes, one broadbill swordfish of 400 pounds—the first *Xiphias gladius* ever caught with rod and reel in New Zealand waters; one black marlin of 704 pounds; 41 striped marlin, ranging from 168 (the only specimen below 200 pounds in weight) to 450 pounds (the world's record) and averaging 268½ pounds; 17 *mako* ranging from 56 pounds (the next smallest being 115) to 300 and averaging 190 pounds. Among other of my catches was a yellowtail of 111 pounds—another world's record.

This extraordinary fishing (surely never surpassed in the angling history of the world) explains why we (Captain Mitchell, my brother R. C. Grey, my son Romer, and I) were all so desirous

R. C. Grey standing beside his 386-pound striped marlin swordfish

of making a second trip in 1927. We did make this trip, as the following account tells in part, but owing to forty-two days of storm we did not equal our first experience.

SOME FISHES FROM THE 1927 EXPEDITION

The strangest and biggest fish we captured on our second expedition to New Zealand waters was a thresher shark (*Alopias vulpes*) of 640 pounds, incidentally the largest ever taken on rod and reel. But I cannot claim the record because, though I got the strike and hooked the fish, I mistook it for a common shark and handed the rod over to my son Romer.

We were fishing off Stevenson's Island, outside of Whangaroa, where some miles off there is a submerged reef of large area. In 1926 Captain Mitchell and I fished this location and also the Cavalli Islands, where I was the first to land a swordfish. Both places have since become popular with anglers. These are indeed magnificent fishing waters. During the summer great schools of *kahawai* and *crevallé* feed there on the surface at certain hours of the day. While feeding, one of these schools will make a rushing noise like the tumbling of a brook over stones. At such times swordfish, *mako* and other sharks abound.

The thresher shark is one of the rare fish of the seas. At Catalina I have had several follow a trolled bait. They stuck their long tails out of the water and struck at the bait with them. Of all strange weapons that have evolved upon fishes of the seas, I think the tail of the thresher is the strangest. If his body is nine feet long, his tail will be ten. When swimming, he can look backward and upward at the tip of this tail and strike very accurately with it, since his eyes are situated almost on the top of his head. He makes one think of a prehistoric monster that has survived to the present.

Three threshers have been caught at Catalina in twelve years—all small ones, around 300 pounds each. Each one was hooked through the tail. They had snagged themselves on the hook while striking at the bait. In New Zealand threshers are caught

pretty often, and run fairly big. Often they leap like greyhounds of the sea, a most unusual and wonderful spectacle. And they are hard-fighting fish.

This 640-pound one that I ran on to in New Zealand, fooled me in the strike. He had not shown on the surface and his bite was nothing much to speak of. But he felt heavy and slow, like a *reremai*—a ground or sand shark—so I gave the rod to my boy with the remark: "Here, Romer, see how quickly you can lick this fish."

Now Romer is a husky lad and has had some luck with big fish. As all boys do, he brags a little. Sometimes seeing me or Captain Mitchell or R. C.[1] in difficulties with a big fish he is prone to remark: "Say, it takes you a long time on that fish. Pull his head off. I could!"

However, Romer met retribution in this thresher. For the first hour he could do nothing with the fish. Meanwhile R. C. came up and made remarks. "Why don't you pull him up? You're weak in the back, boy. We can't hang around all afternoon."

Then Captain Mitchell ran up in his boat: "Hey, Romer, what're you on? We're mighty curious to see if you can lick him." And I said: "Son, for a boy who's a sprinter and who aims for football, you are sure slow as an angler."

Altogether—for the boatmen and his pal, Johnny Shields, got after him too—we made him see red. It really was a mean trick. But Romer himself sometimes plays mean tricks. However, he worked on that fish as he had never worked before on anything—and he has fought some pretty good battles.

At the end of two hours he had the thresher stopped, and in another hour and a half he had him whipped. Really he gave a magnificent exhibition. He blistered his hands, lamed his back, and ruined my rod, but he whipped the thresher.

When the great fish came up so we could see him, I certainly sustained a shock—and I have seen a great many remarkable sea-creatures come up out of the deeps. He was a huge, grotesque, frightful, and terrible fish to gaze

Capt. L. D. Mitchell with his 976-pound black marlin swordfish

[1]My brother R. C. Grey.

ZANE GREY CONGRATULATING HIS SON ROMER ON THE CAPTURE OF THE 640-POUND THRESHER SHARK

upon. All my fishing years I had longed to catch a great thresher. Here I had struck one—a record—and had turned the rod over to my son! The joke was on me.

The thresher must be classed as a game fish. He fights deep most of the time and is exceedingly stubborn. Comparing him with the *mako*, he is pound for pound a harder fish to whip.

The *mako*, however, is the aristocrat of all sharks. It is really unfitting to call him a shark at all. I seldom use the word with regard to him. And after he attains some weight—say over 400 pounds—he is indeed a magnificent sporting fish. His leaps are prodigious, inconceivably high above the water. The ease and grace of this leap is indescribable. It must be seen. He comes out slick, glides up, turns a somersault, and goes down head first, like a diving gull, almost without a splash. Then instantly he is out again. Seldom does a *mako* leap once only. I have had one go up six times—a most thrilling sight. His third leap is always the highest.

The *mako* seems to be known only in New Zealand and Japanese waters. He attains huge size, up to 2000 pounds. Captain Mitchell hooked one in 1926 that leaped twice—the first time scaring us nearly to death, and the second giving us time to judge his weight fairly at around 1200 pounds. Needless to state here, that *mako* is still roaming the sea. Some day, though, we will catch one that large or even larger.

We caught two black marlin in New Zealand waters in 1927, both small fish—340 and 380 pounds. Quite a comedown from our 1926 fish of 704 and 976 pounds. However, the capture of any black marlin is an event to be proud of, and 1927 was a bad season because of rough waters. Captain Mitchell's fish, the larger of the two, leaped out of the water as the captain was winding in the bait, and nearly landed in the boat. The fish was after that bait and he got it. Then he gave

The thresher shark looks like a prehistoric monster

a grand exhibition of fighting on the surface. My black marlin, 340 pounds, charged my "teasers" and bait, and certainly committed suicide.

It is my opinion that fishes of this species do not like rough water, as the striped marlin do. During three months, I had hold of only one, besides that which I caught. I saw this fish heaving up behind my bait and he sure was big. He took it and I struck at him, but—alas!

We saw a very large black marlin, surely a 1000-pounder, riding the swells. It was in shore near the entrance to the Bay of Islands, on the way to my yacht at the close of day when we had no good bait. I put on the only one there was—a *kahawai* stiff as a poker.

We followed this marlin—all three boats—and the closer we got to him as he rolled up in the swells the louder we yelled. If I had known then that we were going to see swordfish in the South Seas twice as big as this one, I might have saved my breath. But there are lots of things we do not know until they happen. Anyway when I got my bait in front of this marlin and he sheered off after it, I nearly had a fit. He refused to take it. We followed, and made careful approach to drag the bait again before him. He came to it and swam clear round it. We were sure he would bite. He did not. Then I did have a fit.

My brother, R. C., struck a striped marlin off the Cavallis which gave perhaps the greatest surface exhibition I ever saw. This fish was one of the long slim ones, as marlins go, but he was so swift in his leaps that we could not train the cameras on him, and so strong that R. C. could just barely stay with him by running the launch full speed.

It was bright sunlight, with just a ripple on the dark blue sea. The marlin blazed in the air, green on the back, striped across his silver-white sides. He cracked the water like pistol shots; he made every kind of a splash, from a thin cutting of spray to a great, angry, boiling maelstrom. The beauty and wonder of such spectacular acrobatics must be seen to be believed and appreciated. Especially must the magnificent fury or fright of this tiger-species be seen. It cannot be adequately described. This marlin weighed 368 pounds, and comes next to my record (450) of 1926.

The Shepherd Fish and Its Strange Pasture Lands

THE REMARKABLE ASSOCIATION BETWEEN THE FISH, *NOMEUS*, AND THE PORTUGUESE MAN-OF-WAR, *PHYSALIA*

By G. H. PARKER
Director of the Zoological Laboratory, Harvard University

FOR a small fish the open sea is a habitat fraught with endless danger. Here he may become the prey of anything that can swallow him; he may be chased and eaten by the larger members of his own tribe; he may be snapped up and swallowed by such sea mammals as the porpoise or the dolphin; and he may be caught by diving birds and carried off as food for their nestlings. Almost nowhere is there safety. A floating bunch of seaweed, a box or a barrel, or even a piece of driftwood may afford a temporary refuge for him that at any moment may prove of vital importance. Around such an obstacle he may successfully dodge his huge pursuer, and in the interior of a mass of weed or of an empty box he may find a sanctuary as secure as a hollow tree for a land animal. Every collector of pelagic fishes knows the meaning of this habit, and, when he is on the open sea in search of small game, he steers for every floating object he sees, scoops it in with his collecting net, and is usually rewarded by a catch of small fry. When we think of the immense waste of oceanic waters with their relative freedom from floating material, we can appreciate to some degree the slim chance for self-preservation that a small fish has. No wonder that he uses every opportunity within reach as a protection against his voracious enemies.

But not everything that floats in the sea is a haven of refuge for the small fish. Whoever has been stung by a jellyfish knows that it is far from being a protection to any creature. Jellyfishes belong to a large group of animals that embraces a great variety of sea creatures including such forms as the corals, sea pens, sea anemones, Portuguese men-of-war, and the like. All these are provided with nettling organs which are best developed on their tentacles and similar parts. These nettling organs serve the double purpose of stinging invaders and thus driving them off, and of killing other creatures that may serve as food. In a number of these stinging animals, as for instance in our common sea anemones, the nettling organs, though present, are so weak that ordinarily they can make no impression on the human skin. Hence we look upon such forms as innocuous. But in others, as for example in the majority of the jellyfishes, the nettling organs are well developed and may inflict upon man not only a severe and painful injury but may poison him so seriously that it sometimes takes weeks for him to recover. Notorious among these more severely injurious kinds is the Portuguese man-of-war, *Physalia*. The tentacles of this jellyfish, if passed over the skin of a human being, may inflict such a vigorous urtication as to throw the person into spasms and leave him in a prostration that may last for many days. This particular species is commonly regarded as the one whose sting is the most vigorous of all marine animals. Both in immediate painfulness and in after effects it is quite comparable to the results of being stung many times by bees or wasps or by a scorpion.

The means whereby a jellyfish or other like animal can sting is of microscopic proportions. The nettling organs of these animals are to be found commonly upon the tentacles that surround the mouth or that hang from the edge of the bell. Such organs appear usually as small swellings on the surface of the tentacle. When these swellings are examined under the microscope, one sees that they contain multitudes of microscopic capsules within each one of which is a spirally twisted filament. If the skin of a fish

The Portuguese man-of-war, *Physalia*, sheltering several shepherd fish, *Nomeus*, amid its tentacles, which bear myriads of nettling organs. Photograph of a model in the American Museum

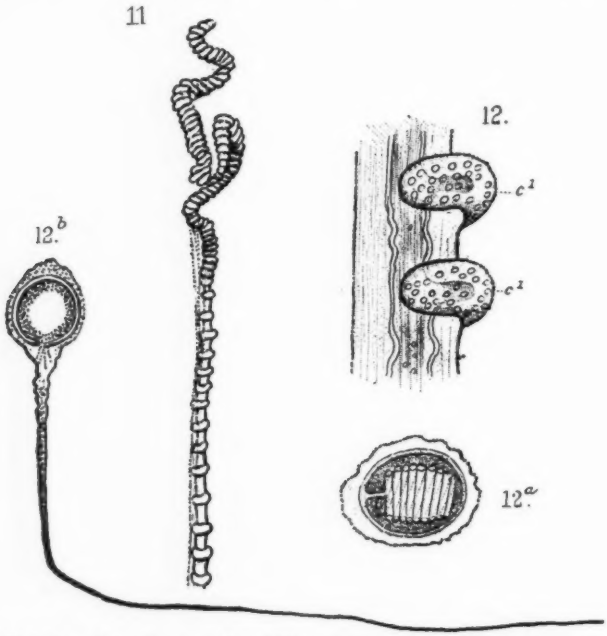
or of a human being comes in contact with a nettling organ, thousands of these minute filaments are shot out and in a very remarkable way penetrate the skin of the creature concerned. Each filament is a hollow tube of extremely fine caliber whose cavity leads into that of the capsule from which the filament has emerged. Through this microscopic tube the minute amount of poison contained in the capsule may be injected into the wound inflicted by the filament itself. Each filament, with its attached capsule, is in fact a microscopic hypodermic syringe which, after insertion under the skin, may continue to inject poison into the creature whose misery or death it may thus bring about. A person stung by a jellyfish is punctured by myriads of such microscopic syringes, each one of which is forcing its irritating contents into the wound produced by its needle. In most jellyfishes these organs of torment are of such a size as to be visible only under the high power of the microscope, but on the tentacles of the Portuguese man-of-war the nettling organs are so large that, when their filaments are discharged, these organs seem to be covered with a fine woolly growth easily visible to the naked eye. The nettling filaments of this jellyfish are in all probability the largest of their kind, and the pain and wounds that they inflict are dreaded by all those who have occasion to touch them.

The Portuguese man-of-war or *Physalia*, as it is technically called, is a native of the warmer waters of the Atlantic and the Pacific oceans. Each *Physalia* consists of a gas-filled sac which floats on the top of the water. From the underside of the sac long purplish tentacles trail a dozen feet or more into the sea. In addition to these tentacles the underside of the sac carries innumerable trumpet-shaped mouths that hang down an inch or so into the sea-water below. The long tentacles are the parts on which the very vigorous nettling organs are situated. The sac or float to which all these parts are attached maintains its position like an inflated bladder on the surface of the water. This float is glassy-clear in its transparency and is tinted in varying shades of blue, purple, and pink. One end of it is pointed, the other is blunt, not unlike the hull of a vessel. The upper part of the float rises into a high, fluted crest, giving the whole the appearance of an ancient galleon under full sail. Nothing is more beautiful than to meet a flotilla of these miniature, brightly colored barks making their way under a gentle breeze across the surface of a tropical sea. They rise and fall with the waves and stand to the wind with such regularity and precision that they recall in a most realistic way a miniature reproduction of the ancient fleets of Spain or of Portugal.

In the blue waters below their diminutive hulls, the long, delicate tentacles with their deadly nettling organs stream out many feet like anchor lines. Almost transparent and of the tint of the blue sea water itself, one of these tentacles may be struck by an unwary fish. Instantly batteries of nettle capsules are discharged with the double result that the fish is made to adhere to the tentacle at the same time that it is seriously poisoned. Its struggles excite the tentacle to shorten and thus the victim is drawn up nearer to the clusters of sucking mouths. Its movements, moreover, bring it into contact with other tentacles, in this way making its capture doubly certain. Sooner or later the fish, if not

too large, is entirely overcome by the poisonous injections and is drawn up to within range of the numerous mouths which spread their trumpet-shaped lips so generously over the benumbed prey as to cover it entirely. Digestion proceeds in this semi-external position and the resulting juices and fragments of the partly digested fish are sucked up by the mouths and elaborated as food for the man-of-war as a whole. It is not unusual to find Portuguese men-of-war with the remains of several partly digested fishes still held to the underside of the float. Sooner or later these are cast off, for the jellyfish certainly catches many more fishes than are necessary for its food.

Could a Portuguese man-of-war be improved upon as a device to catch small creatures in the open sea? As a floating object it naturally attracts fishes in consequence of the protection it appears to promise. But long before they reach it they may collide with one of its numerous tentacles which, as already explained, are arranged to kill, hold, and transport to the mouths any fish of reasonable size. Even the struggles of the fish increase the certainty with which it will be brought to its end. Thus in all respects the Portuguese man-of-war is an admirable death trap for small fishes.



Details of tentacle and nettling organ from the Portuguese man-of-war. No. 11—a slightly magnified portion of a tentacle showing the transverse swellings. No. 12—two of these swellings enlarged to show the embedded poison capsules (c′). No. 12a—one of the undischarged capsules (c′) with its coiled thread, greatly enlarged. No. 12b—one of the discharged capsules with its extended filament. Redrawn from Huxley (*Oceanic Hydrozoa*, 1859, pl. X).

Notwithstanding the deadly nature of the *Physalia*, there is to be found under its float and in among its poisonous tentacles a small fish, the *Nomeus*, which lives in this situation with apparent impunity. This fish is found

commonly only in association with the man-of-war. There is no obvious reason against its independent occurrence in oceanic situations but, as a matter of fact, when it is not taken in immediate association with a man-of-war it is not far separated from the jellyfish, and in regions where its occurrence is periodic it comes and goes with this particular form. The species of *Nomeus* that is thus associated with the *Physalia* has been reported from the Indian Ocean as well as from the warmer parts of the Atlantic Ocean. Its maximum length is about four inches. In consequence of the large black patches on its body and of its pair of broad, fan-shaped ventral fins it is by no means inconspicuous. The most ready way of obtaining it is to dip up with a large net any Portuguese men-of war within reach; under many of these one or more *Nomeus* may be taken. They often show considerable range in size and as many as ten have been reported from a single *Physalia*. The most remarkable peculiarity in the whole situation is that though other small fishes in the same locality as *Nomeus* would quickly meet with death, this fish finds its environment among the tentacles of *Physalia* so favorable that, as already explained, it is seldom found elsewhere.

This little fish was first described by Gmelin in 1788 under the name of *Gobius gronovii* in honor of Gronovius, a senator of Holland and one of the ablest students of fishes in his day. The name was changed in 1817 by the great French naturalist Cuvier to *Nomeus gronovii*. In Homeric Greek *nomeus* is the shepherd or pastor and the latter name is often applied as the common English designation for the fish. Why Cuvier should have chosen the name *Nomeus* for the fish is difficult to conjecture. As a matter of fact these little fishes are more like a herd of sheep than is any one of them like a shepherd. It is probable that Cuvier's employment of the name is a loose use of language. But however this may be, the pasture land of *Nomeus* is certainly a remarkable one, for it is the region circumscribed by the tentacles of *Physalia*. In this relatively limited space much of the life of *Nomeus* is passed, a space in which apparently no other kind of fish can easily live.

What are the mutual relations of *Physalia* and *Nomeus* that this association of the two forms should be maintained? The answer to this question can be at best only conjectured. The presence of *Nomeus* among the *Physalia* tentacles probably induces other small fishes to enter the deadly territory and thus helps in providing *Physalia* with an abundant food supply. More or less of this supply in a partly digested condition falls to the share of *Nomeus*. But the chief advantage of the combination that accrues to the fish is the possession in the open sea of a territory peculiarly its own. No other inhabitant of the ocean can trespass on this strange pasture land without danger to its life. How *Nomeus* accomplishes the invasion so successfully is unknown. Is the fish immune to the deadly poison of the *Physalia* or does its skin contain a substance that prevents the discharge of the nettle capsules of the jellyfish? These and other like questions can be answered only by a further study of *Physalia* and *Nomeus*.

A Barn-door Skate (*Raja stabuliforis*) with Abnormal Pectoral Fins

By LEWIS RADCLIFFE
Deputy Commissioner, U. S. Bureau of Fisheries

THE strap-gilled fishes (the Elasmobranchii), so called because they lack the gill covers of our bony fishes and have the gill openings separated by "straps" of skin and flesh, are divided into two groups, the sharks and rays. In typical sharks the body is spindle-shaped, there is a pointed head with laterally placed gill-openings, and a well developed caudal fin which serves as the chief organ of locomotion, while the pectoral and smaller pelvic fins serve chiefly as balancers. In the typical rays the head and body are greatly depressed, the gill openings are on the under surface, while the pectoral fins are markedly expanded, and have become the chief organs of locomotion, the tail and fins being much reduced. Such forms are adapted to a life on the floor of the ocean.

Between the representative forms of the two groups just described, are intermediate types which practically bridge the gap. For instance, the angel sharks (Squatinidæ), of which *Rhina squatina* (Fig. 1) is an example, fit in admirably here. *Rhina* is raylike, with a broad flattened body, a terminal mouth, with pectoral fins larger and more expanded than those of a shark but not nearly so large as those of a ray and separated from the head by a distinct notch. Its gill openings are partly lateral, and its dorsals, placed rather far back, are smaller than a shark's, but much larger than a ray's. And finally, the caudal fin is, like the other organs, intermediate in type. *Rhina squatina*, as the figure shows, is a shark plainly on the way to becoming a ray.

Other raylike sharks (more raylike than the preceding) are the saw-fishes (Pristidæ), which are commonly classed as rays because the anterior part of the body is depressed, the mouth and gill openings inferior, pectoral fins continuous with the head in front (lacking the notch found in *Rhina* between the front margin and the head) but with a well-developed sharklike tail. Still less sharklike are the guitar-fishes (Rhinobatidæ). They have the body deeply depressed anteriorly, with inferior mouth and gills as in the preceding group, but with the pectorals placed far forward and definitely confluent with the prolonged snout—markedly raylike in these anterior parts. Posteriorly the tail is still sharklike, but somewhat flattened and having a prominent fold of skin on each side.

The transition to the skates (Rajidæ) is marked by a greater lateral expansion of the body and pectoral fins to a rhomboidal shape. The pectorals, which extend to but not around the snout, represent practically the only organ of motion. The pelvic fins are poorly developed, the caudal region has become a slender tail, and the dorsal fins are placed near its tip, in most forms. Finally, in the last and most specialized of the rays (*Disceus*) the body is extremely flattened and the pectoral fins meet and fuse not merely before but practically behind—encir-

cling the body and making it disc-shaped.

If, then, the skates are elasmobranchs of a more highly specialized type than the sharks, their early embryos must go through a shark stage in their development. That this is true is well known to embryologists, less so to zoölogists in general, and not at all to the public at large. One of the most interesting things found in baby skates is that, as they "climb their own ancestral tree," their pectorals are first of the typical shark-fin form, free from the head anteriorly. As development proceeds, the fin grows anteriorly faster than fusion takes place with the head laterally, but this fusion proceeds steadily, and finally the pectorals become confluent with the head as is found in the normal skates and rays.

Fig. 1.—The angel shark, *Rhina squatina*. Note the notch between the pectoral fins and the head. After Boulenger, 1904

However, development (fusion, etc.) does not always take place uniformly and normally, and occasionally skates are taken in which the fusion of the pectoral fins and the head has never been completed, giving the animal a very grotesque appearance. While such teratological forms are not common, they are not unknown, and a number of accounts are found of cases of such abnormalities.

In 1924 an abnormal skate of this kind was taken at the Bureau of Fisheries Laboratory at Woods Hole, Massachusetts. On careful study this proved to be a young specimen of the barn-door skate (*Raja stabuliforis* Garman). This species is common in the Gulf of Maine, and is our largest skate, reaching a length of six feet or more. This teratological specimen (Fig. 2 herein) is an immature male, the measurements for which are as follows: total length 20.5 in.; length, tip of snout to tip of ventral fins 11.75 in.; length of tail from hinder margin of vent to tip 10.25 in.; length of head from tip of snout to a line joining the bases of the right and left notches 5.25 in.; tip of snout to bottom of right notch 5.5 in., to base of left notch 5.25 in.; width of base of head at notches 3.2 in.

From these measurements it will be seen that the fish is slightly asymmetrical in its abnormality—the right notch being deeper than the left as

may be seen in Fig. 2 (dorsal view). Turning now to the ventral surface (Fig. 3), it will be seen that this later abnormality results also in an abnormal

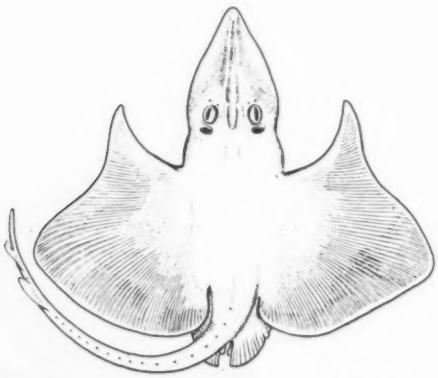


Fig. 2.—An abnormal specimen of the barn-door skate, *Raja stabuliforis*, from Woods Hole, Mass., in which the pectoral fins have failed to unite with the head

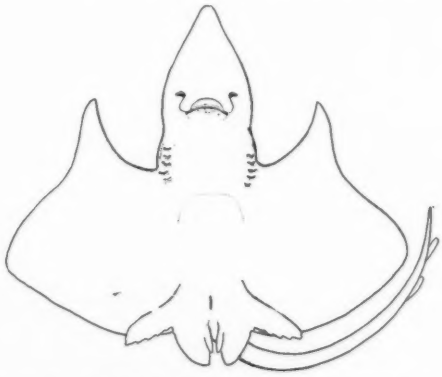


Fig. 3.—Ventral view of the abnormal *Raja stabuliforis*. Note that there are three gill slits above the notch on the right and but two on the left

placement of the gill slits—on the right side three gill slits are above or forward of the notch and on the left only two are so placed. Other than the points named (notches and gill slits) the ray seems to be normal—it is simply a young barn-door skate in which the embryonic condition, where the pectorals have not fused with the head, has persisted into its post-larval life.

This teratological condition in rays has long been known, but all that can be done here with the literature is to refer to some of the earliest accounts in which such rays were, interestingly enough, described as new genera and species, and to some later outstanding articles in which the matter has been effectually cleared up.

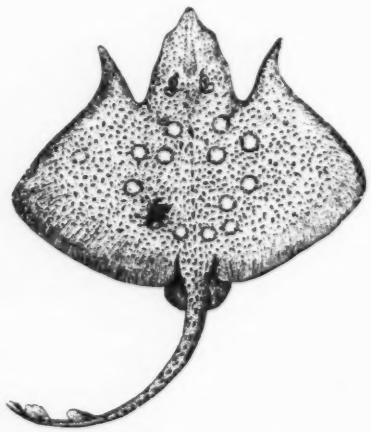


Fig. 4.—Flemming's *Hieroptera abredonensis*, a skate with the same type of abnormality as that in Fig. 2. After Flemming, 1841

The first writer to describe such rays seems to have been the Breslau naturalist, A. W. Otto.[1] In 1818, Otto, while in Edinburgh, obtained from a fisherman there the curiously shaped ray which he figured and described in 1821 as a new genus and species—*Propterygia hypostica*, (Fig. 5 herein). This figure, plainly made from a dried specimen, differs markedly from that of the Woods Hole fish. Here we have the same failure of the anterior edge of each pectoral to unite with the side of the head. But back of this there has been a splitting of each pectoral into an anterior band-shaped part and a posterior and vastly larger part con-

[1]Otto, A. W. "Ueber eine neue Roche (*Propterygia hypostica*)" etc. Nova Acta Academiæ Leopoldino-Carolinæ, 1821, Vol. 10, 113–121. 2 pls.

taining most of the fin structures. In other words, it looks as if this ray had four pectoral fins, two anterior and smaller thumblike fins, and two posterior larger hand-shaped real fins.

This specimen was a small one—only 9.5 inches over all (body 5 and tail 4.5 inches long) and 7 inches wide. The head stretched 2.25 inches beyond the point where the pectorals joined it, and was 2 inches wide at its base.

Otto knew nothing of the embryological history of rays, but he did know something of the great ray called *Cephaloptera* (*Manta*) which has projecting forward from the head two cephalic fins, and he did not fail to call attention to the rather marked similarity between his fish and it. (See Fig. 6). However, he recognized that his was not a *Cephaloptera*, and gave it the name noted above—Propterygia = fins in front of the [true] fins—to account for its rarity, and conjectured that it "lives in much greater depths of the ocean than most rays."

The next describer of a ray with malformed pectorals was John Flemming.[1] His specimen (shown herein as Figure 4) came from Aberdeen Bay in July, 1840. It was 18 inches long (equally divided between body and tail) and 13 inches wide. The head was 3.3 inches long, and its breadth 4 inches. The horns of the pectorals were each 2 inches long and 1.8 inches broad at the base. The fish was an immature female.

Since he could not assign it to any known form, Flemming erected for it a new genus and species, *Hieroptera* (priest wings) *abredonensis* (from Aberdeen). However, he recognized its affinity to Otto's *Propterygia* and to *Cephaloptera*. It is, of course, apparent to the reader from Flemming's picture that it is a ray showing the same malformation—only in lesser degree—as is found in the Woods Hole specimen.

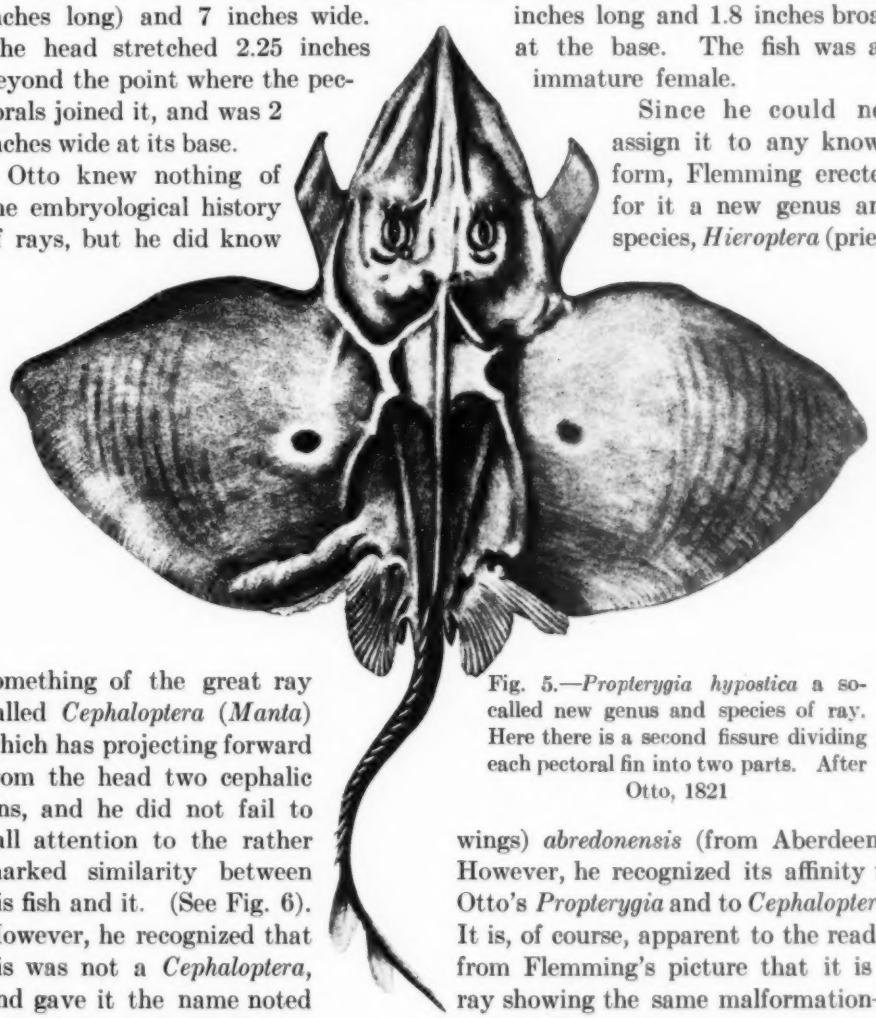


Fig. 5.—*Propterygia hypostica* a so-called new genus and species of ray. Here there is a second fissure dividing each pectoral fin into two parts. After Otto, 1821

That these rays were merely abnormal was pronounced by the two men who first systematized our knowledge of the elasmobranchs—Müller and Henle.[2] In the preface to their

[1] Flemming, John. "Description of a Species of Skate New to the British Fauna." Edinburgh New Philosophical Journal, 1841, Vol. 31, 236–238, 2 pls.

[2] Müller, Johannes und Henle, Jacob, "Systematische Beschreibung der Plagiostomen." Berlin 1838–41, preface, pp. viii-ix.

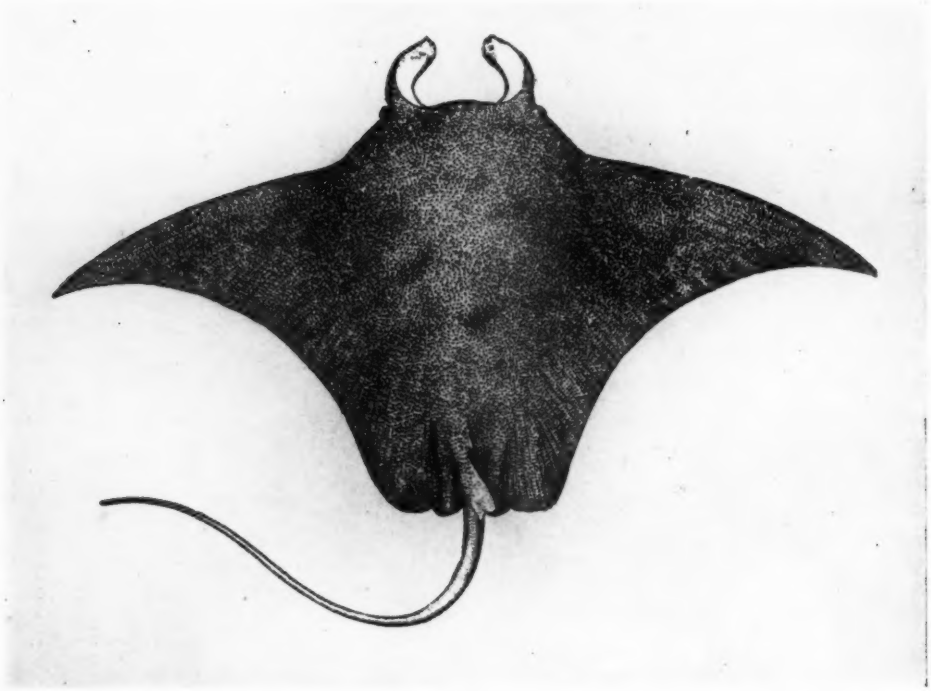


Fig. 6.—Dorsal view of the giant ray, *Manta* (cloak), akin to *Cephaloptera* (head-finned). The two anteriorly projecting cephalic fins give it the specific name *birostris* (*two-horned*). After Jordan and Evermann

book, they refer to such pathological features in rays as Otto figured and described, and say that *Propterygia* cannot be made a new genus, since it is merely an abnormality.

Müller and Henle's remarks are more or less incidental, not so, however, those of the eminent Danish ichthyologist, Lütken[1], who reviews all the literature of these abnormal rays as known to him, and comes to this definite conclusion:

> As reasonable as it seemed 40 or 50 years ago that these ray-forms were special genera and species, just so clear will it appear now that they are nothing but deformities (monstrosities) and belong to one or another [well known] species of rays.

Lütken then "clinches" the matter by taking up each abnormal ray in the literature known to him, and by assigning it to a certain well-known genus and species. Thus *Propterygia* and *Hieroptera* are reduced to synonymy.

And finally, Dr. Theodore N. Gill,[2] our most critical student of the nomenclature of fishes, in discussing these and other names given to rays, settles the matter once for all in the following clear-cut statement:

> There is a liability in any skate to an arrest of development in the growth of the pectoral fins forward and consequently their continuity with the head, but in most of such cases there is an independent extension forward from the base of the pectorals. Such anomalies have received generic names, *Propterygia* having been proposed for one phase of development and *Hieroptera* for another.

[1]Lütken, Chr. "Smaa Bidrag til Selachiernes Naturhistorie. (Om vanskabte Rokkeformer)." Videnskabelige Meddelelser, 1879, ser. 4, Vol. 1, 45–55. textfig.

[2]Gill, T. N. "Notes on the genus *Cephaleutherus* of Rafinesque, and Other Rays with Aberrant Pectoral Fins (*Propterygia* and *Hieroptera*)." Proceedings United States National Museum [for 1895] 1896, Vol. 18, pp. 195–198.

As has been noted, there is a fair amount of literature dealing with this abnormality. However interesting it would be, consideration of this would unduly expand this article, and hence its study must be left to another hand. For the references, the student is referred to the *Bibliography of Fishes* (Vol. III, p. 603) by Bashford Dean, E. W. Gudger, and A. W. Henn. However, it will be of interest to bring the present account to a close by presenting the oldest known figure of this abnormality.

This is found in Ulysse Aldrovandi's huge folio, *De Piscibus*, Bononiæ [Bologna] 1613, p. 443, and is reproduced herein as Fig. 7. This figure is not original with our Italian author, but is said to have been copied from Conrad Gesner. Search has been made through all the works of Gesner available but unfortunately the original has not been found. The ray from which this figure was made has evidently been dried and artificially distorted, but it is plainly a case of *Hieroptera*—priest wings—a ray with abnormal pectorals. It seems plain, too, that such a fish is probably the original of the curious and unusual figures of monk-fishes, priest-fishes, and bishop-fishes, with which the pages of such old naturalists as Aldrovandi and Gesner, to say nothing of the lesser lights, are filled.

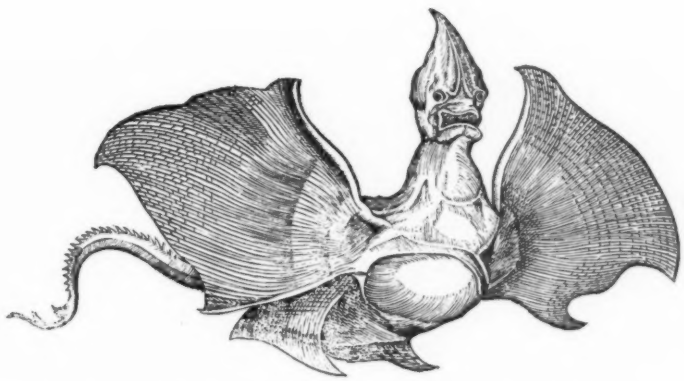


Fig. 7.—Gesner's "Spitzrogen," the earliest known figure of a ray with malformed pectorals. The artist has given pretty free rein to his imagination in making this drawing. After Aldrovandi, 1613

About Flying Fishes

By J. T. NICHOLS,
Curator of Recent Fishes, American Museum
AND C. M. BREDER, JR.
Research Associate, New York Aquarium

IT has recently been the good fortune of the writers to study an exceptionally interesting collection of flying fishes brought back by the "Arcturus" expedition of 1925, under the direction of Mr. William Beebe. A report on this collection will shortly appear in *Zoologica*, the technical series of the New York Zoological Society. Meanwhile, the readers of NATURAL HISTORY will, we think, be interested in various facts and problems concerning flying fishes.

The ability to indulge in more or less protracted aërial excursions is known to have arisen independently in four present-day groups of fishes, and in at least one fossil group. These groups are:

THE AFRICAN FRESH-WATER FLYING FISH (*Pantodon*), a small species related to the herring-trout group.

THE SOUTH AMERICAN FRESH-WATER FLYING FISH (*Gasteropelecus* and related genera), belonging to the tropical family *Characidæ*, which is related to catfishes and minnows.

A FOSSIL HAPLOMID (*Chirothrix*), related to our pikes and pickerels.

TRUE FLYING FISHES (*Exocoetidæ*) a large marine family, all the members of which have powers of flight. They are related to the slender halfbeaks, billfishes, etc.

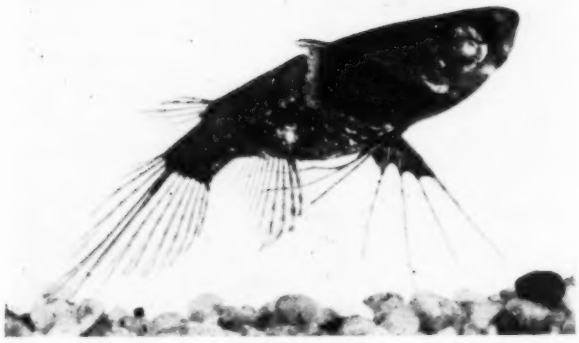
THE FLYING GURNARD (*Dactylopterus*) one of the mail-cheeked fishes, related to the sea-robins and sculpins.

Thus we see that several unrelated groups of fishes have developed independently the ability to fly. However, the true flying fishes (*Exocoetidæ*) characteristic of the trade-wind belts of open, tropical oceans, excel all others in aërial powers, and furthermore, we have here a large and varied group of aviators, not merely one or a few related species with powers of flight. It is also of interest that the flying gurnard is the only member of the great modern group of spiny-rayed fishes (*Acanthopterygii*) to have developed the fin equipment necessary to support it for even a short distance in the air. Its close relatives are bottom-dwelling fishes which lunge upward into the free water above them, and then coast down again to the bottom, with fins set. The flying gurnard's flight is somewhat analogous to this habit, the difference being that the fish leaps into the air, where its relatively large breast fins are able to support it for a short journey.

Aside from the flying gurnard, the other four groups of flyers are all less modern fishes of more primitive organization, perhaps more closely related to each other than any are to the flying gurnard.

Of the fossil *Chirothrix* we naturally know little. In this form it was the ventral fins which were most enlarged, placed anteriorly, close to the pectorals. Though it is not universally admitted that the fish was a flyer, such is the most reasonable hypothesis advanced to explain its fin development.[1] Of the African and South American fresh-water flying fishes, the former, *Pantodon*, sometimes kept in balanced aquaria, has very slight powers of flight. The South American *Gasteropelecus* is a relatively better flyer, especially con

[1]Landois, 1894, *Neues Jahrbuch Mineralogie*, Stuttgart, II, p. 228–235.



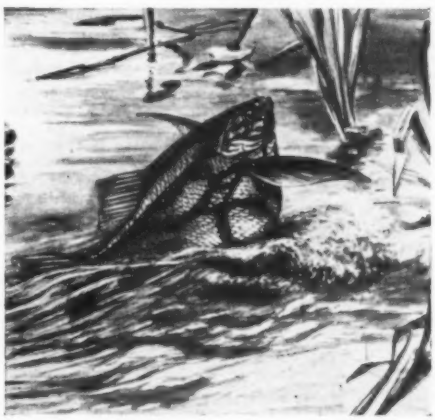
The African fresh-water "flying-fish" *Pantodon*, from a photograph by Dr. E. Bade

sidering its small size. It is said that it flaps its pectoral fins vigorously during passage through the air. The structure and muscles of this interesting form are described in detail in the *Annals and Magazine of Natural History* for 1913.[1]

With this short résumé, we will turn to a more detailed discussion of the true marine flying fishes familiar to all who venture on blue water. Their abundance and world-wide distribution bespeak the success which has come to them by invasion of that realm for the most part held (among backboned animals) by birds.

The first question which comes to mind is "Why do flying fishes fly?" Undoubtedly the chief use of flight to these fishes is that thereby they escape predaceous enemies. The rapid approach of a submerged body, such as the hull of a ship, will cause them to rise into the air and soar for several hundred yards or more. The larger species fly singly, the smaller ones frequently leave the water in a glistening silver "flock" or "shoal," and they may soar for several hundred yards or more before dropping back into their native element. To pursuing enemies, for whom the surface of the water is virtually a ceiling to be avoided, this ability on the part of their prey must be a source of considerable and frequent disappointment.

By "banking" to right and to left, flying fish can alter the direction of their course. In the daytime they are able to see where they are going, and seldom fall aboard ship. At night not being able to see, they frequently strike against the rigging and fall to the deck. The dolphin (*Coryphæna*), perhaps the swiftest fish that swims the open sea, feeds largely on flying fishes. It frequently thrusts its head and shoulders clear of the water to seize them, and will follow under water the curving shadow of a fish above with astonishing speed, ready to seize it when it descends. At the same time it is probable that most of the individuals captured by the dolphin are those which by some mischance are slow in gaining the air, or which do not



The South American fresh-water flying fish, *Gasteropelecus*, from a drawing by Dr. E. Bade

[1]Ridgewood, 1913, *Annals and Magazine of Natural History*, (8) XII, pl. 544–548, pl. XVI.

make a perfect flight. Flying fish fly much more frequently in a fresh breeze than when it is calm and in light air. Under optimum conditions they seem to do so from exuberance as well as for refuge.

A second natural question would be, "How do flying fishes fly?" This introduces a problem that has bothered naturalists, aëronautical engineers, philosophers, and others for a long time. There is today anything but unanimity of opinion on this subject. The argument as to whether these fishes sustain their flight by motion (flapping) of the wings or merely soar as gliders, has not been satisfactorily settled. There is some truth in both points of view. The flight is largely a planing one, but at certain times and under certain conditions a definite wing motion may enter in and contribute to it. The enlarged pectoral fins or "wings" are, on anatomical grounds and structurally—from an engineering point of view—ideal gliding planes, so arranged as to be easily held rigid at the proper angle. R. E. Dowd[1] has worked out the structure of the flying fish wing from an aëronautical point of view, and arrived at the conclusion that it is extremely well "designed" for planing, but not for a flapping flight.

The wings of large flying fishes are sometimes seen to vibrate or flutter, a motion more reasonably referable to tension in setting them, or to the wind, than to a definite function in flight. In very small and young fishes, on the other hand, the wings vibrate to such an extent that they blur, like those of a flying insect. It seems that with an increase in age and size, a buzzing beelike flight is replaced by a true soaring flight, and that the former is very likely a function of absolute size as are so many larval specializations. Flying fishes fly more freely in a strong breeze, and attain greater elevation, speed, and distance than in calm weather. The conclusion is almost inevitable that they utilize the wind to some extent to lift and propel them, even though it is difficult to understand how this would be accomplished.

A detailed description of the flight of one of the larger flying fishes may be quoted from C. L. Hubbs (1918, *Copeia*, No. 62, p. 85–88) as follows:

> The details of the flight of *Cypselurus californicus*, never described with sufficient fullness, may readily be observed by a person at the bow of a small vessel plying through the sea off the coast of southern California, during the summer months. Seemingly indifferent to the direction of the wind, and without apparent unison in their flight, these flying fishes scatter before the boat, as Dr. Jordan says, like grasshoppers before one walking in a meadow.
>
> They appear never to leap directly into the air, as some species are said to do, but, on emerging from the water with greater or less velocity, they immediately spread their wide pectoral "wings" and move forward on the surface like tiny aeroplanes, for a distance averaging perhaps twenty-five feet. While on the water, their sole source of propulsive power appears to be the normal organ of locomotion in fishes—namely, the tail. The pectoral fins, to be sure, are seen to vibrate, but apparently with neither sufficient amplitude nor velocity to propel the fishes forward on the surface, nor to raise them from the water. The vibration of the "wings," though claimed by some to indicate true flight, seems to be due to the less evident, but still observable shaking of the whole body, which in turn is evidently caused by the rapid side-to-side sweeping of the strengthened lower lobe of the caudal fin. The greatest movement of the "wings" is toward their tips, apparently because the fin is rather flexible distally, and because the amplitude of motion is much increased so far out from the body. The moment the fishes rise into the air, their

[1]Dowd, R. E. 1921, The Aeronautics of the Flying Fish. *Aerial Age Weekly*, Jan. 10, pp. 464–465. 3 figs.

THE BUTTERFLY FLYING FISH

Enlarged 1¾ times

Young of a "four-winged" flying fish (*Cypselurus furcatus*). Its mottled color, unlike that of the adult (see next plate) is doubtless correlated with a habit of hiding about drifting weed. It is one of those species the young of which have a double barbel on the chin. From a painting by Helen Tee-Van

A FOUR-WINGED FLYING FISH

Slightly reduced

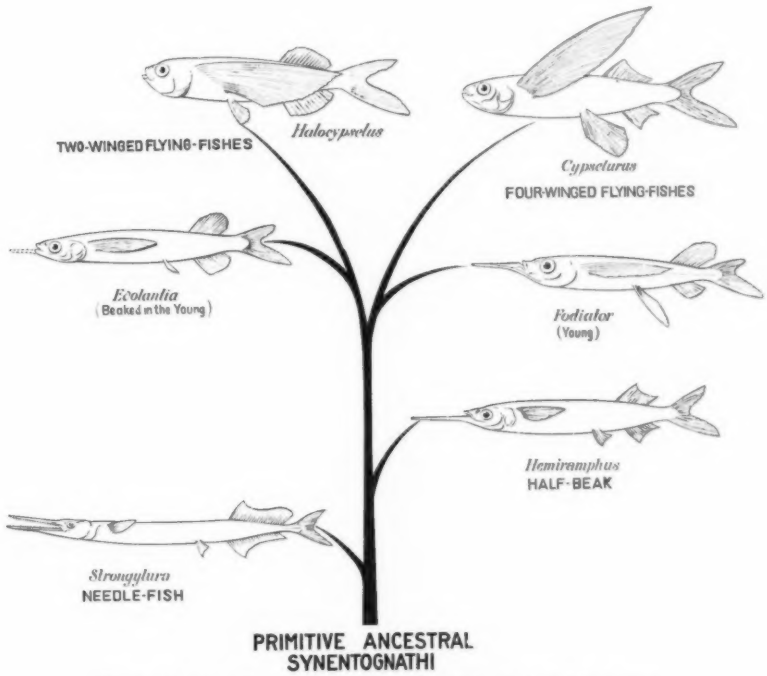
An adult "four-winged" flying fish (*Cypselurus furcatus*), with ventral fins placed posteriorly and enlarged to function as secondary planes. Its color matches that of the "two-winged" species of similar habitat. It measures about six inches "over all" when full grown. From a painting by Helen Tee-Van

A TWO-WINGED FLYING FISH

Slightly reduced

One of the "two-winged" flying fishes (*Halocypselus evolans*). Its beautiful blue color matches that of the open ocean, and is characteristic of animals which float or swim unattached at the surface on "blue water." When full grown this fish attains a length of about six inches. From a painting by Helen Tee-Van

pectorals are held taut: when viewed from the rear they are seen clear-cut, like knife edges. It is very probable, therefore, that not only while on the surface, but in the air The turning is apparently accomplished by the tail and tail fin, which are seen bent in the direction toward which the course is being altered.



Tentative family tree of the needle-fish, flying-fish group

as well, the great pectoral fins (of this species, at least) are not flapping wings, but rather planes of support.

While the flying fishes are attaining on the surface the velocity necessary to carry them soaring away through the air, the ventral fins, also enlarged in *Cypselurus*, remain close-folded against the body. Suddenly they are broadly spread, as elevating planes, and the fish gracefully rises into the air. During the flight the ventrals seem to serve an additional purpose: for, when observed from the advantageous position directly in line with the course of flight, these fins may be seen repeatedly changing their plane, sometimes independently. Apparently serving thus as stabilizing planes, they seem to keep the course of the fishes through the air rather steady, even in a gale. No such regulatory movement of the pectoral fins is apparent.

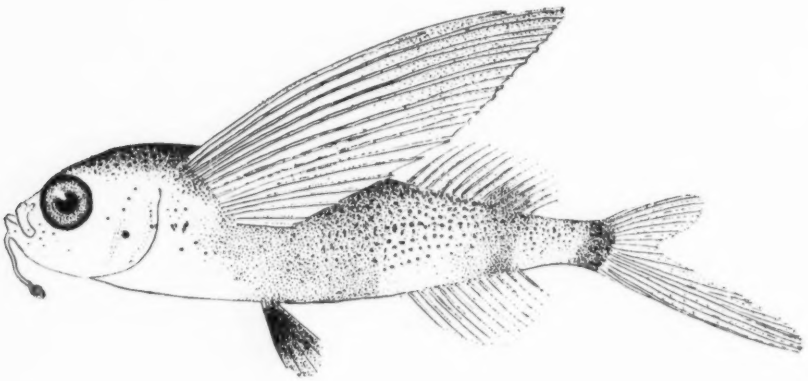
The flight of these fishes is often straight in direction, but not invariably so; when well under way it may even become semicircular.

During their flight, the fishes seldom rise higher than about five feet (though they may be farther above the trough of the swells), except when forced upward by a gust of wind. The length of the initial flight, unless following a very poor start, varies usually between fifty and three hundred feet; but when flying with the wind, distances of about a quarter mile in the air are occasionally made.

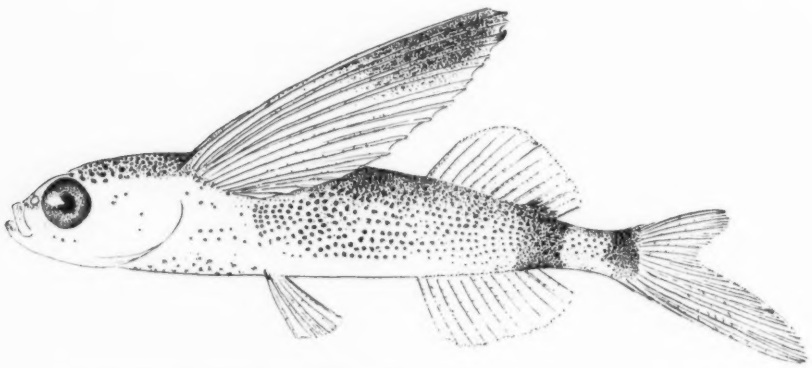
While in the air, the body appears to be arched upward, and the tail is held lower than the head. As the flight reaches its end, the force of gravity having gradually overcome the upward thrust of air pressure against the pectoral planes, the lower caudal lobe strikes the water first, and the ventral fins are folded. The fishes now either suddenly end their flight, or continue it, they being in the same position as when they first came to the surface. The second flight is a repetition of the first. The necessary velocity to propel them through the air is again attained on the surface by the rapid movement of the tail,

which begins as soon as the caudal fin touches the water. Two or three successive flights are frequently made, and occasionally four, or even five, are undertaken before the fishes finally sink beneath the surface. Usually the flights are of increasingly shorter distance and duration; at the end of the last the pectoral fins, as well as the ventrals, are instantly folded, and the fishes drop into the water with a splash. They light in a horizontal position, ready for their dashing movements which are seen for a second under the surface.

Owing to the greater resistance offered by the water, changes in the direction of movement are much more swiftly accomplished in that medium than in the air. Sometimes they soar straight toward the side of a vessel, until they seem about to crush themselves. But they suddenly plunge into the water, twist directly backward in their course within a radius of about ten feet, and make away in the opposite direction, either in the water or in the air.



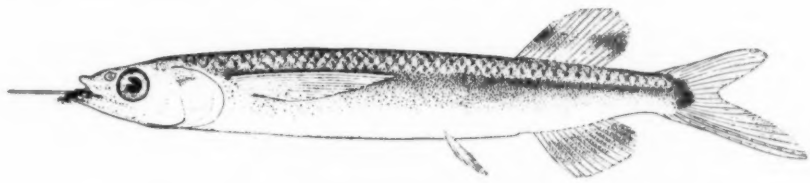
Young two-winged flying-fish, *Halocypselus obtusirostris*. The barbel will distinguish it from the common *H. evolans*



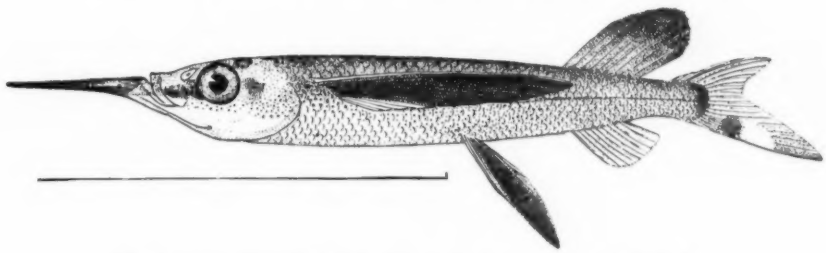
Young two-winged flying-fish *Halocypselus evolans*. To give the scale, a reference line of one inch accompanies this and the other figures

Now let us consider the relations between different flying fishes, from what manner of fish they have been developed, the trend of evolution in this group. There is little question that they are descended from some billfish-like ancestor, through the half-beaks. The billfish, or marine gar is a

long, slim-bodied fish with excessively elongate jaws armed with sharp teeth to the tips. In billfishes the habit of leaping out of the water is notably developed, more than in most fishes, a halfbeaks, frequently come more or less clear of the water at an angle with its surface and, leaping and skittering along, are virtually dancing on their tails. From this we have the name



The beaked young of *Evolantia microptera*, a primitive flying fish



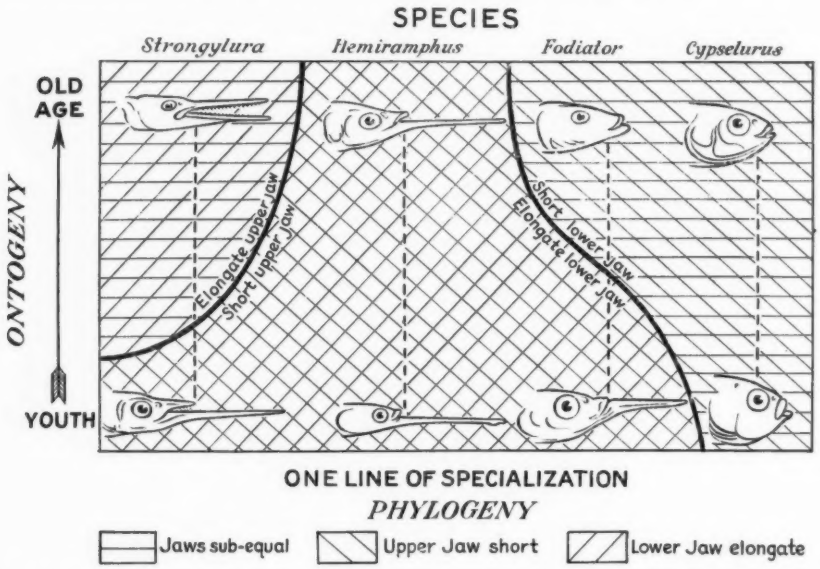
The beaked young of *Fodiator acutus*, a primitive flying fish

vigorous under-water locomotor apparatus being capable of projecting them into and through the air as a dart or javelin might be thrown. In very young billfish the upper jaw is much shorter than the lower, probably associated with some specialized larval feeding habit. All the evidence, which we cannot go into here, points to the halfbeaks as being in a sense "fixed larvæ" of the billfish group. This is another way of saying that the short upper jaw originally developed by small billfish as a larval specialization was later retained by some of these (primitive halfbeaks) to the adult condition. As the billfishes are active leapers, so the flying fish group already had at least the beginning of an aërial habit before the development of specialized wing (fin) structures, correlated with that habit's extension. Some of the billfishes, and particularly of the applied to them throughout the Spanish Main, "ballao," corrupted to "ballyhoo." It is noteworthy that the more flying fish-like and the less billfish-like the series becomes, the greater is the pectoral fin (wing) development, and the prolongation of the lower caudal lobe, the latter obviously a character of service in skittering along the water, or in throwing the fish into the air.

It is noteworthy that the pectoral musculature of the halfbeaks is approximately as great as that of the flying fish, which suggests that this mass of muscle is necessary to hold the pectoral fins rigid as planes. They function as such in the halfbeaks as well as in the flying fishes, but on account of their lesser surface only succeed in raising the head instead of the entire body.

In one of the more primitive flying

fishes, (*Fodiator*), the young have a long lower jaw like that of a halfbeak, which is gradually reduced with age, until the adult has only a pointed chin.



Evolutionary diagram showing greater duration of the half-beak character in young than in adult

In most of the species the jaws have become quite short, undoubtedly much as in some remote ancestors, even antedating the billfishes. Another primitive flying fish (*Evolantia*), with short wings, has a "half-beak" in the young which is of a different character from that of *Fodiator*. With the growth of the fish, this projection does not merely lag; seemingly the normal thing is for the skin of the beak to break away from its slender central supporting cartilage, the cartilage then breaks off, and the skin heals on to the chin. A peculiar specialized character, present in the young of some species of flying fishes and absent in young of others, without any known reason, and a character without any known function, is a single or double barbel, frequently large, or fringed, hanging from the chin. Lacking any other explanation, one may fancy some homology between such barbels and the skin of the beak in *Evolantia*.

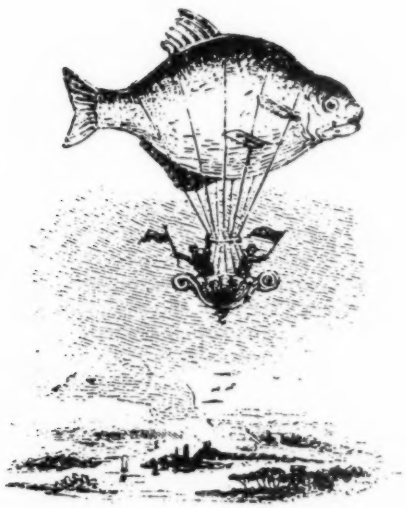
Specialized flying fishes divide themselves into two groups, according as the pectorals only are used as planes in flight, or the ventrals also, placed farther back, are enlarged and function as secondary planes. The first group are sometimes spoken of as two-winged, the latter group as four-winged flying fishes, and the two seem to have been derived respectively from primitive forms resembling *Evolantia* and *Fodiator*.

Our study of the flying fishes of the family *Exocoetidæ* indicates for them a family tree the main features of which are explained in the diagram on page 73.

This group shows certain progressive modifications of its variant characters very prettily. Certain notable changes, which are somewhat involved, we have attempted to show in the appended diagram. A progressive shortening of the

jaws is shown in the top row of heads (*Strongylura* to *Hemiramphus*, and *Fodiator* to *Cypselurus*). This may represent phylogenetic development along one line of specialization in one character. Then along the bottom row of heads we have indicated the young of these same genera, so that reading vertically one finds the ontogenetic development of each form from youth to old age. Thus with ontogeny and phylogeny as ordinates, various curves may be plotted, delimiting the reduction of either jaw both with reference to phylogeny and ontogeny. Reading from the left to the first curve, we have the long upper jaw only in the adult form of *Strongylura*. To the right of this line we have all small upper jaws. Reading to the second curve, we have long lower jaws which reach from the young of *Strongylura* to *Hemiramphus* and to the young of *Fodiator*. To the right of this line we have both jaws short. The cross-hatching emphasizes this overlap. One thing that this method of plotting brings out forcibly is that the *Hemiramphi* amount to fixed larval *Strongyluræ*—whereas the long lower jaw of young *Fodiator* is simply the retention of an ancestral character in young stages.

THE FLYING-FISH.



Tail piece to the chapter on "The Flying Fish" in Yarrell's *History of British Fishes*, Vol. 1. Possibly engraved by Thomas Bewick

On the Association of the Common Goby (*Gobiosoma bosci*) with the Oyster, Including a Case of Parasitism[1]

By THURLOW C. NELSON
Professor of Zoology, Rutgers University

THERE is no group of fishes, the various species of which are more interesting in their many and diverse habits, nor more appealing in their droll appearance, than the gobies. These gobies are mainly tropical, and among them are those famous fishes which hop along the beaches or even climb trees in search of prey. One species, however, the common brackish-water goby, *Gobiosoma bosci*, Lacépède, may be found in numbers on the oyster beds within a few miles of New York City and, though less spectacular than its "terrestrial" and "arboreal" relatives of the tropics, it is not less interesting.[2]

THE COMMON GOBY AND ITS HOME

A little search among the gaping shells of dead oysters on an exposed flat at low tide, or on the deck of an oyster boat as the oysters are being dredged, will generally yield several specimens of this little fish. If one of these is dropped into a dish of brackish water, it will quickly demonstrate some of those traits of behavior for which the gobies are so well known. As it darts clumsily about the dish in search of some shelter from the light, one thinks not so much of a fish swimming as of a rabbit hopping on its forelegs, with the hind legs bound together and trailing out behind it.

Swimming is accomplished by quick, jerky movements of the pectoral fins aided by the tail, but unlike most fishes seen in an aquarium, the goby is incapable of hanging poised in the water or of gliding gracefully about, owing to the absence of an air bladder. It must remain in contact with the bottom save during the brief intervals when it darts from one shell to another.

Viewed from the side, the fish is seen to rest on its confluent pelvic fins (which form a body very similar to a grocer's scoop), and it is also supported by the anal fin as is shown in Fig. 1, or by the whole posterior part of the body as may be seen in Fig. 2. Sometimes one or the other of the pectorals is used as a support when the fish reclines on its side. Rarely are both pectorals in contact with the bottom as is shown in Fig. 3. When the fish does have these outspread, it usually lists slightly to right or left, leaning more on one pectoral than on the other and often with the tail bent sharply toward the same side to give additional lateral support—as is clearly shown in Fig. 4. The fish may remain quietly in this position for long periods, with body and fins motionless, the only movement being the rhythmical rising and falling of the opercula in respiration. Now and then the fish rolls its bulging eyes from side to side in a manner comical to see, and when attracted by some object, the goby may turn the head

[2]The writer is indebted to Mr. J. T. Nichols and to Dr. E. W. Gudger, of the American Museum of Natural History, for identifying the specimen and for valuable references and suggestions.

[1]From the Zoological Laboratory of Rutgers University, Publication No. 8, New Jersey Oyster Investigation Laboratory.

Fig. 1.—The goby with the elevated anterior part of the body resting on the conjoined pelvic fins. The anal fin and the right pectoral fin aid in preserving equilibrium

Fig. 2.—The goby reclining at ease on its right side, the head somewhat elevated, the posterior part of the body resting on the bottom of the aquarium

slightly to one side or the other without moving the body.

The mature male measures approximately 50 millimeters (2 inches) in length. In color a grayish-brown, transversely marked with ten[1] narrow, yellow bands (which in the male become brilliant during the breeding season) with the head and the bases of the pectorals blotched with deep brown, the goby is well colored to render it inconspicuous when on the bottom. Such protection can be of only occasional use to the fish, however, for it spends most of its time concealed between the gaping shells of dead oysters or clams in which the ligament still holds the shells together.

[1]Jordan and Gilbert give "seven to eight paler transverse bars."

FOOD AND FEEDING HABITS

In its secluded hiding-place, the goby finds abundant food in the copepods which pass in with the surrounding water, and in the small polychaete

Fig. 3.—The goby resting on the bottom with the pectoral fins outspread to keep it from turning to one side

Fig. 4.—The goby with outspread pectoral fins and tail turned to one side. This is a favorite attitude with this goby

worms (*Nereis limbata*) which abound in clusters of oysters or shells wherever there exist narrow crevices into which they may crawl. If a small *Nereis* is added to an aquarium, a hungry goby will "hop" rapidly toward it and, seizing the worm in its strong toothed jaws, will shake it vigorously as a terrier might shake a rat. When most of the "squirm" has been shaken out of the worm it is eaten.

A most interesting food relation involving the goby and the living oyster is indicated by observations on one of the English gobies, *Gobius microps*, at the Fisheries Experiment Station, Castle Bank, Conway, England. The heaviest fall of oyster spat occurred in one of the tanks containing a number of gobies which were not present in the other tanks. It is the belief of Doctor Dodgson, director of the Station, and of his associates, that the gobies through reducing the numers of copepods present left a relatively much larger food supply for the larval oysters in the tank. The food of the larval oyster is not definitely known, but the investigations which have been in progress for several years at Castle Bank, England, and the work of Spärck (1927) in Denmark, indicate that minute organisms such as *Chlorella* probably play a predominant rôle. Since copepods and their larvæ also live on such organisms, it is probable that any reduction in the numbers of copepods present would make available more food for the oyster larvæ.

BREEDING HABITS

In late May and early June in New Jersey, as water temperatures approach 68° F., the gobies associate in pairs in gaping oyster or clam shells and here the eggs are laid. The eggs of the goby are not deposited in a rounded mass such as Dr. E. W. Gudger (1927a) has recently described for the gunnel, but each egg, enclosed in an oval, transparent, tough capsule, is cemented fast by one end to the inside of the shell. The capsules are placed as close together as possible, forming a veritable mat of egg cases, each standing on end, Figs. 5, 6. When an area of shell from one to two inches square has been covered by the capsules, the egg-laying stops and the male remains inside the shell to protect the eggs from enemies. As Doctor Petersen (1917) of the Danish Biological Station says: " . . . the males exhibited a most touching care in guarding the eggs so that neither crabs, starfishes, nor other intruders might devour them.'"

Two stages in the development of the young gobies are shown in Figs. 5 and 6. The ovoid capsules, though thin and quite transparent, are very tough, and afford a degree of protection to the little fish within, which is surpassed only by the egg cases of some of the skates. In addition to this tough covering, the young benefit from the watchful care of the male for, as in most fishes which remain with their young, it is the father that is left at home "to care for the children." Perhaps this curtailment of his freedom sours his temper; at any rate he becomes very pugnacious and vigorously resents any attempt to enter between the shells which shield his little brood. After several weeks the young hatch, and as Doctor Petersen and his coworkers have shown, there follows a pelagic or free-swimming period at the surface after which they take up their abode between shells such as those which sheltered them during their embryonic development.

PARASITISM OF AN OYSTER BY THE GOBY

As might be expected where two animals live in as close an association as do the goby and the oyster, an occasional instance of that most intimate association, parasitism, may result. In a fish as large as the goby such parasitism, if it covered the entire life span of the fish, could not but be detrimental to the existence of the species and hence would not be perpetuated. Such instances of parasitism as do occur are to be looked upon as purely accidental, but they hold great interest for the zoölogist as indicating ways in which complete parasitic relationship may be entered upon within the life span of two single individuals. Such instances hold still further interest since cases of true parasitism among vertebrates are, with the exception of certain groups of normally parasitic fishes, very rare, (Gudger, 1927b).

Associations of fishes with bivalve molluscs are well known, but in each instance the fish is at most a harmless commensal, spending usually only its larval life within the gill chamber of the mollusc. Such is the case reported by Welsh in which specimens of the giant scallop taken between Montauk Point and Cape May within the twenty-fathom curve were found to harbor within the gill cavity the young of the squirrel hake, *Urophycis chuss*, ranging in length from 27 to 70 millimeters (1 inch to nearly 3 inches). The whole story of this relationship is not known, but since neither fish nor mollusc apparently undergoes any modification as a result of this association, it is probable that the young hake make use of the protecting shelter of the scallop shells for but a short period early in their development.

A closer relationship between fish and bivalve mollusc is that of the much elongated fish, *Fierasfer*, which lives within the mantle cavity of the pearl oyster, *Meleagrina*, in the warmer American waters. As it uses the oyster merely as a place in which to hide,

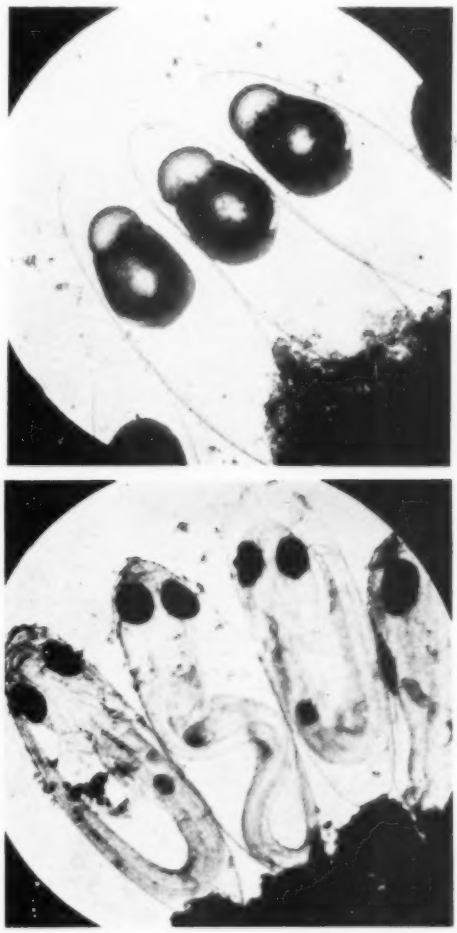
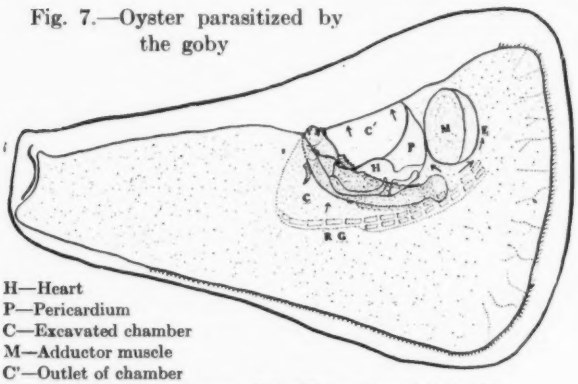


Fig. 5.—(Upper) Photomicrograph of the egg capsules of *Gobiosoma* containing eggs with early embryos lying on the yolk sac. Fig. 6.—(Lower) young gobies within the egg capsule nearly ready to hatch. The yolk sac has been completely absorbed. Note the very black eyes and transparent bodies of these fish which soon are to enter upon a pelagic existence where their transparency will aid them in escaping their enemies

These figures magnified approximately 30 diameters

making frequent excursions into the surrounding water, it is looked upon by some zoölogists as not even a commensal but as a lodger. Occasionally one of these fish forces its way between the mantle and the shell to a point anterior to the adductor muscle. In this position it may become lodged and covered with a layer of mother-of-pearl as shown by specimens in the U. S. National Museum, the American Museum, and the British Museum. (Fig. 8). Another fish of similar habits, probably *Oligocottus*, has also been found entombed in "nacreous splendor" on the surface of the shell of the pearl oyster (Stearns, 1889). The fishes *Batrachus* and *Ophidium* may also occur occasionally in oysters (Dekay, 1842).

Fig. 7.—Oyster parasitized by the goby



H—Heart
P—Pericardium
C—Excavated chamber
M—Adductor muscle
C'—Outlet of chamber
E—Normal excurrent stream RG—Water tubes of right gill

A somewhat more specialized instance of fish-mollusc association which bears certain parasitic aspects is that of the bitterling of Central Europe, which, with the aid of a long ovipositor, introduces its eggs into the mantle cavity of the fresh-water mussel. Protected by the shells of the mussel the eggs develop into young fry, which then leave to complete their growth outside the mussel.

The reverse relationship, mollusc on fish, affords a case of true parasitism. In the well-known life history of the fresh-water mussel, the glochidia or young attach themselves to the fins or gills of fishes, and here we find in some species a high degree of specificity involving even immunity.

The parasitism of the goby on the oyster here reported represents an instance of true parasitism entered into during the life-span of two individuals, accompanied by marked structural modification of parasite and of host finally reaching a state of equilibrium. An oyster 80 millimeters (3 inches) long, dredged by the writer in Maurice River Cove, Delaware Bay, July 30, 1926, was found to contain a goby 21 millimeters (nearly 1 inch) long. The fish was lying, not in the gill chamber as are the common oyster crabs, *Pinnotheres*, which so often turn up in an oyster stew, but actually imbedded in the soft parts of the oyster. (Fig. 7.) The fish, while still very young, probably soon after the close of the pelagic period, had apparently entered between the shells on the dorsal side of a living oyster anterior to the adductor muscle. Here there is an area of relative quiet, undisturbed by either incurrent or excurrent streams of water, and from which the oyster would have great difficulty to expel the invader. Taking up its abode just anterior to the adductor muscle, the fish, apparently through movements of the tail and posterior part of the body, had gradually effected an invagination in the oyster's dorsal body wall to the right of the intestine which passed anteriorly for 12.5 millimeters (½ inch).

The invagination of the oyster's

body continued ventrally into the right suprabranchial chamber into which was discharged the water which passed through the gills. The bottom of this invagination was in direct communication with ten of the water tubes of the right outer gill and with four tubes of the inner right gill. As a result of this modification, a considerable portion of the outgoing stream of water which normally leaves the oyster posterior to the adductor muscle must have passed through this new exit anterior to the muscle, flowing over the goby as it lay in this invagination. The pectoral fins which in the normal goby are broadly rounded (Fig. 3), showed in this specimen a distinct development of the upper fin rays, apparently to aid the fish in holding its position in the invagination.

Not only had the fish formed a new channel for at least a part of the outgoing water from the gills, but the heart of the oyster which normally lies in a dorso-ventral position anterior to the adductor muscle, was displaced so as to lie almost in an antero-posterior direction. In spite of these two marked anatomical changes there was no evidence at the time of capture that the oyster was suffering any distinct ill effects from the presence of its unbidden guest. This, together with the high degree of structural modification, indicates that the relationship was one of rather long standing, perhaps two or three years, during which equilibrium had become established.

The goby, though but 21 millimeters long, was swollen with eggs, showing it to be a dwarfed specimen

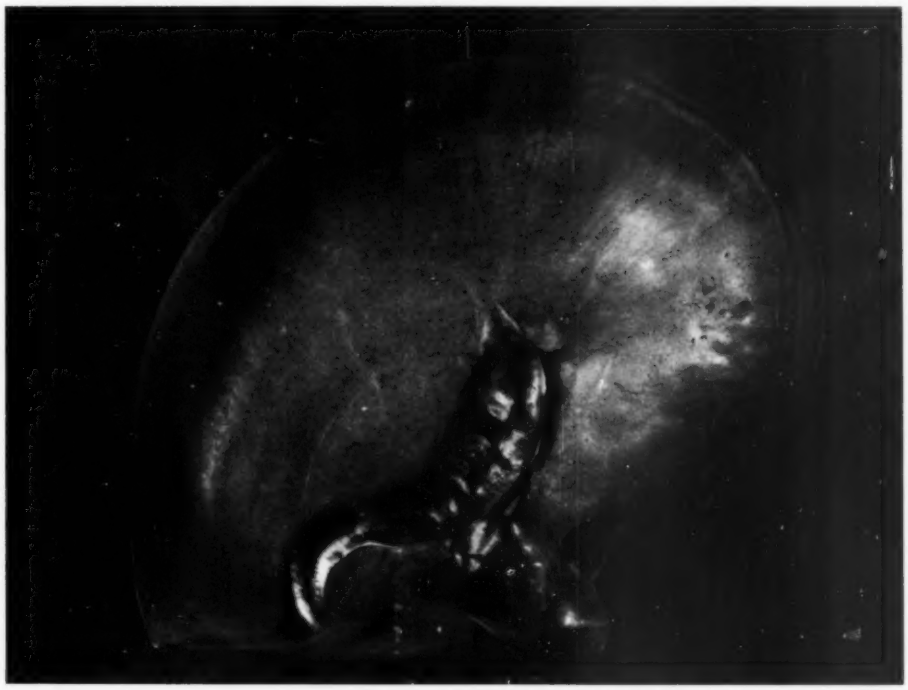


Fig. 8.—A small fish (presumed to be a *Fierasfer*) embedded in and covered over with the nacreous layer of the inside of a pearl oyster (*Melcagrina*). Photograph of a specimen in the American Museum

much older than its size indicates. Hand in hand with the dwarfing went that companion change almost invariable in parasitism, hypertrophy of the sexual organs. In the absence of a male no spawning had occurred, as is evidenced by the fact that this specimen was full of eggs almost two months after the close of the normal breeding period of the goby.

The source of the food of this goby can only be conjectured. The outgoing stream of water passing over the fish had already gone through the oyster's gills where every organism larger than a small bacterium would have been removed. The surrounding water, therefore, could have brought the goby nothing of use to it save oxygen. Its food, then, must have consisted of small worms, copepods, and other animals which, like itself during its first wanderings, passed into the quiet area along the dorsal side of the oyster seeking protection.

In this unique relationship between the oyster and the goby we get a glimpse of the wonderful powers of adaptation of animals to changed conditions. Just when the relationship of goby to oyster was entered into, we have no means of knowing but, from the unusual degree of modification resulting therefrom, it probably occurred when the goby was but a few weeks old and at a time when the oyster was not more than two or three years old.

Similar instances of association in varying degrees must have occurred many times in the oyster beds of the world, but serving no purpose to either oyster or fish, they were not perpetuated. They represent striking cases of failure drawn from nature's vast laboratory; unsuccessful experiments among the great mass of animal associations from which have sprung the very complex cases of symbiosis and of parasitism now known to us.

BIBLIOGRAPHY

DEKAY, J. E. 1842. The Zoology of New York or the New York Fauna. New York Geological Survey, Vol. 1, pt. 4.

DODGSON, R. W. "Notes on Oyster Breeding Experiments for 1921, 1925, 1926." Multigraphed Reports of the Fisheries Experiment Station, Castle Bank, Conway, England.

GUDGER, E. W. 1927 (a). "The Nest and the Nesting Habits of the Butterfish or Gunnel, *Pholis gunnellus*." NATURAL HISTORY, Vol. 27, pp. 65–71. 4 figs.

GUDGER, E. W. 1927 (b). "Fishes that Live in the Mouths or Gill Cavities of Other Fishes." *Scientific Monthly*, Vol. 24, pp. 556–558. fig.

LEBOUR, M. V. 1919. "The Young of the Gobiidae from the Neighborhood of Plymouth." *Journal Marine Biological Association*, Plymouth. Vol. 12, pp. 48–80; 146–148.

1920. "The Eggs of *Gobius minutus*, *pictus*, and *microps*." *Journal Marine Biological Association*, Plymouth. Vol. 12, pp. 253–260.

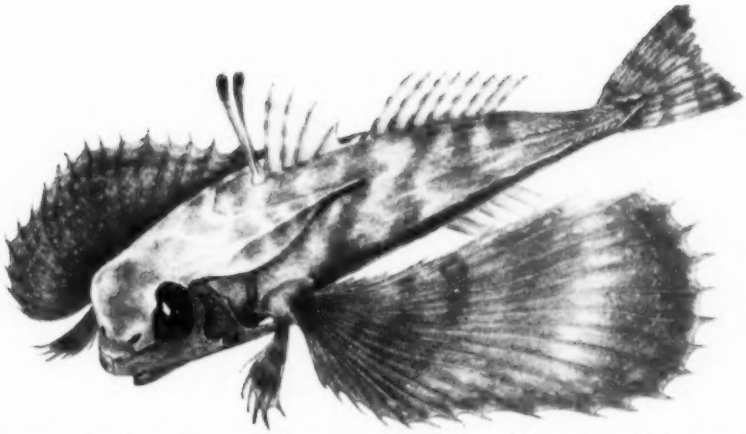
NELSON, T. C. 1926. "Parasitism of the Oyster by the Goby." (Abst.) *Anatomical Record*. Vol. 34, pp. 164–165.

PETERSEN, C. G. J. 1917. "On the Development of our Common Gobies (*Gobius*) from the Egg to the Adult Stages." *Report Danish Biological Station*, for 1916, Vol. 24, pp. 5–16. pl.

SPÄRCK, R. 1927. "Studies on the Biology of the Oyster (*Ostrea edulis*). II. The Feeding and Growth of the Pelagic Larvæ." *Report Danish Biological Station*, Vol. 33, pp. 46–56.

STEARNS, R. E. C. 1889. "On Certain Parasites, Commensals and Domiciliares in the Pearl Oysters, Meleagrinæ." *Smithsonian Report for 1886*, Part 1, pp. 339–343. 2 pls.

WELSH, W. W. 1915. "Note on the Habits of the Young of the Squirrel Hake and Sea Snail." *Copeia*, No. 18, pp. 2–3.



Flying gurnard, showing wings made from expanded pectoral fins. The little "hands" represent the separate forepart the pectoral fin. Note the streamline form of the body and the helmet of bony skin

The Versatile Gurnard

SOME OBSERVATIONS ON THE REMARKABLE ACTIVITIES OF THE FLYING GURNARD, *CEPHALACANTHUS VOLITANS*

By WILLIAM BEEBE
Director, Department of Tropical Research, New York Zoological Society

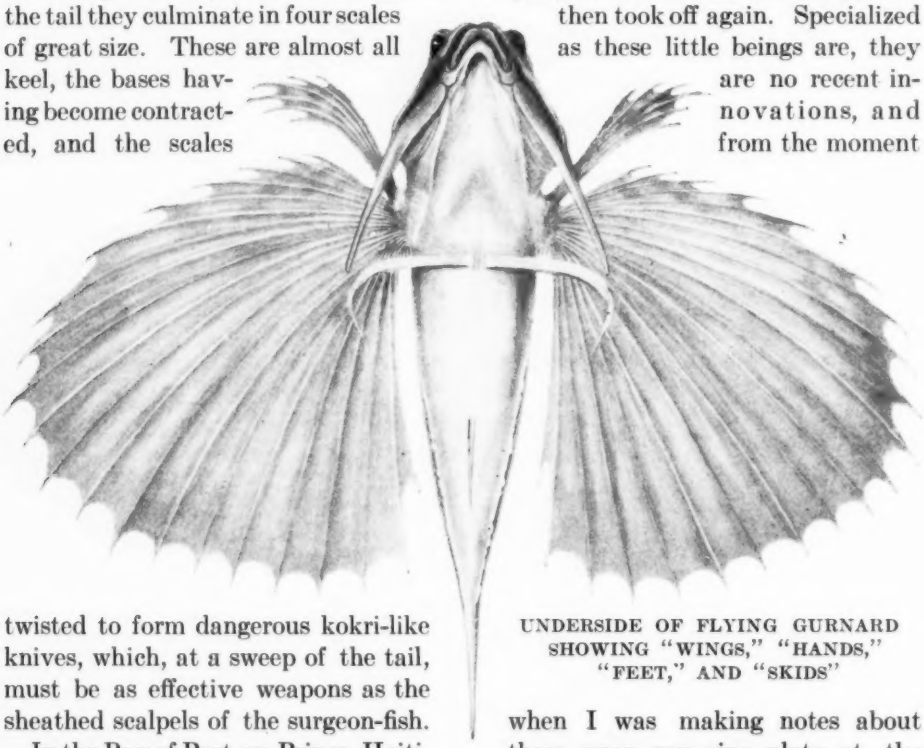
A flying gurnard, from the point of view of limb function, finds its nearest allies among bats and angels, its fins functioning distinctly as hands, feet, and wings. As regards the scope of its life activities it is almost in a class by itself, for while angels and bats have conquered only two elements, a flying gurnard is at home not only in water and air but is able to trot easily about on solid earth. In fact the latter seems to be its favorite mode of progression.

I have seen gurnards rise and scale away from the path of a vessel, and I have had a school of half-grown ones slap against the side of a rowboat. In the young fish the fins are too short for flight but even a two-incher will leap out and spread his diminutive batlike wings, only to flop back at once. At best they are less skillful *aviateurs* than the true flying fish. This is reflected in many body characters such as the wing support, the tips of the pectoral rays being simple and not multiple-branched. The head of the gurnard is encased in solid, heavy armor. To offset this excess of weight anteriorly there is a monoplane arrangement placed far forward, the expanse of actual flight membrane being considerably greater than in the more familiar synentognathous flying fishes. Gurnards may be said to have great muzzle velocity but comparatively little trajectory or range. One of these fishes has been known to knock a sailor senseless by a head-on blow between the eyes, as the man stood at the wheel of a schooner.

A secondary use for the great wing expanse is as a float. Several times, in widely separated oceanic areas, I have seen gurnards, either singly or in a school, sunning themselves at the very surface, with the wings widely spread, floating buoyantly with only occasional flicks of the caudal fin.

I see no reason why a gurnard should fear any enemy or need the power of flight for anything except pursuit of

food or pleasure, for it is one of the thorniest, least edible objects of the sea. To the rear of the cephalic armor and spines, the body is covered with ivory-hard, razor-ridged, thorny scales, which increase posteriorly until at the base of the tail they culminate in four scales of great size. These are almost all keel, the bases having become contracted, and the scales twisted to form dangerous kokri-like knives, which, at a sweep of the tail, must be as effective weapons as the sheathed scalpels of the surgeon-fish.



UNDERSIDE OF FLYING GURNARD SHOWING "WINGS," "HANDS," "FEET," AND "SKIDS"

In the Bay of Port-au-Prince, Haiti, on the recent tenth expedition of the New York Zoological Society, I found young gurnards coming occasionally to the submerged light at night, swimming slowly along with half-spread pectorals. They allowed themselves to be caught with ease. One evening, while visiting Mr. H. H. Rogers' yacht not far from our anchorage, I won eternal fame as a fish charmer by leaning over the gangway platform and allowing a small gurnard to swim straight into my hand—my astonishment being quite as great as that of the captured fish.

When wearing a diving helmet and sitting quietly on the bottom of a coral reef three or four fathoms down, I have seen small gurnards, individuals measuring from two to four inches in length. These swam slowly, and frequently alighted gently on a sprig of coral or on a sponge, examined it carefully, and then took off again. Specialized as these little beings are, they are no recent innovations, and from the moment when I was making notes about them upon my zinc plate at the bottom of the sea, back to the time when toe earliest flying gurnard flew over and walked in Eocene seas,—all this is a matter of not less than fifty million years.

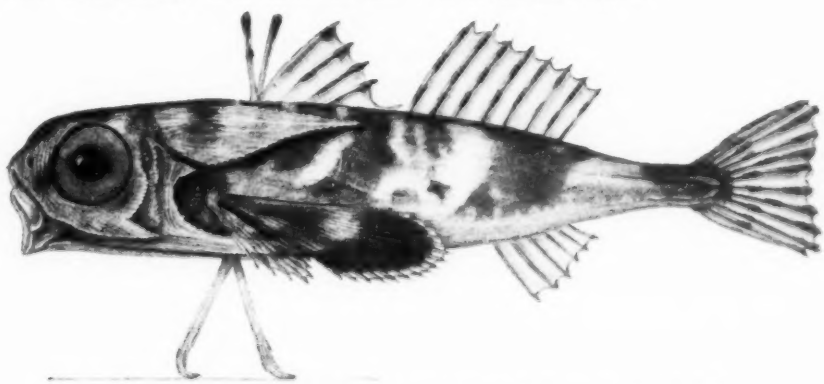
In large aquariums on my Haitian schooner, I watched these fish at leisure and was astonished at their peripatetic facility. Every movement brought to mind a strange, half-living aëroplane. A gurnard volplanes swiftly downward from the surface, wings tightly folded, and when close to the bottom turns slightly upward, partly spreads its pectorals and, stretching out the long, thin ventral fins, alights gently, and at once trots off,

scampering here and there, now and then actually holding up one leg fin, as the fish pivots slightly and looks about. When it walks forward rapidly the body is kept almost horizontal, with the tail clear, but when it slows down and begins taxiing across the floor of the aquarium, the caudal fin drops and the lower rays drag, like the tail stick of an aëroplane.

The leglike ventral fins work alternately, one after the other, and each step is effective, sometimes directly ahead, or again to one side or backward. These fins are remarkably long, the fish standing very high; when in action they are constricted, appearing slender and perfectly straight, only the very tips of the rays bending back and functioning as feet. Every now and then the anterior free portions of the pectorals stretch out and down, fumbling about as though searching for something.

In front of the first dorsal fin are two free rays, long, slender, and knobby at the tips, and for their entire length quite separate from the rest. When the fish begins walking, these separate laterally and act as balancers, one on each side, forming an angle of about forty-five degrees. If the gurnard turns quickly or trips up, one of the two rays quickly dips down on the corrective side, exactly as a person's outstretched arms assist in regaining lost balance. The motion pictures which we were able to secure of the walking gurnard show all of these unpiscine refinements.

As I dived day after day, and walked about the coral reefs of Haiti, I was ever more deeply impressed with the astonishing uses to which the fins of fish are put. I saw a dozen or more species which actually, and not as a mere figure of speech, deserve the term walking, while in as many more I watched the pectoral fins being used to turn over bits of coral or to fan loose strands of seaweed away from some edible morsel. Even in this first season's brief study of reef life I saw the occupation and sturdy defense of definite homes, I noted curious sleeping postures and quarters, and extremes of emotion which were reflected not only in the bodily actions and in the motives of the fish, but in the instantaneous shift of individual pattern and color beyond anything which I had ever considered possible. All this serves to bring closer together the lives of these lowly vertebrates and those of our more familiar terrestrial two- and four-footed fellow creatures, who share with us today this little whirling ball of earth and water.



Young flying gurnard, showing "legs" made from the ventral fins

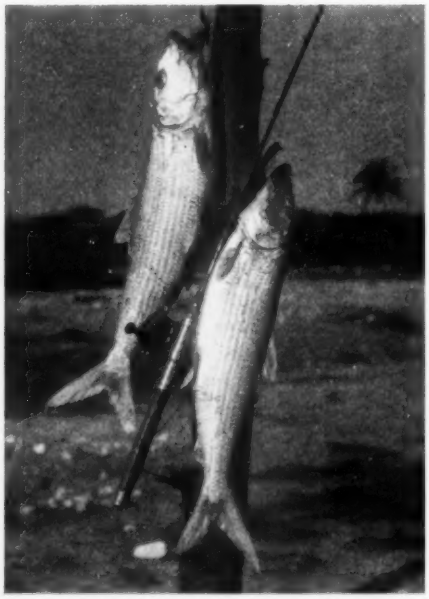
In Southern Waters After Bonefish

ANGLING AMONG THE FLORIDA KEYS AND THE BAHAMAS FOR THE GAMY *ALBULA VULPES*

By VAN CAMPEN HEILNER
Field Representative in Ichthyology, American Museum

OF all the game fishes which it has been my fortune to pursue with rod and reel, none has given me greater sport or greater thrills and enjoyment in the catching than the bonefish (*Albula vulpes*). To my mind he is the gamiest fish of any size or species in either fresh or salt water that an angler can hope to take.

My early experiences with bonefish occurred among the Florida Keys, that chain of coral and mangrove islands which stretches southward and westerly from southern Florida. Here the great mud or marl flats are favorite feeding grounds for these finny warriors and many a winter's day I have spent poling about the banks in a skiff in search of them.



In the writer's opinion, nothing in fresh or salt water can compare with the bonefish for gameness

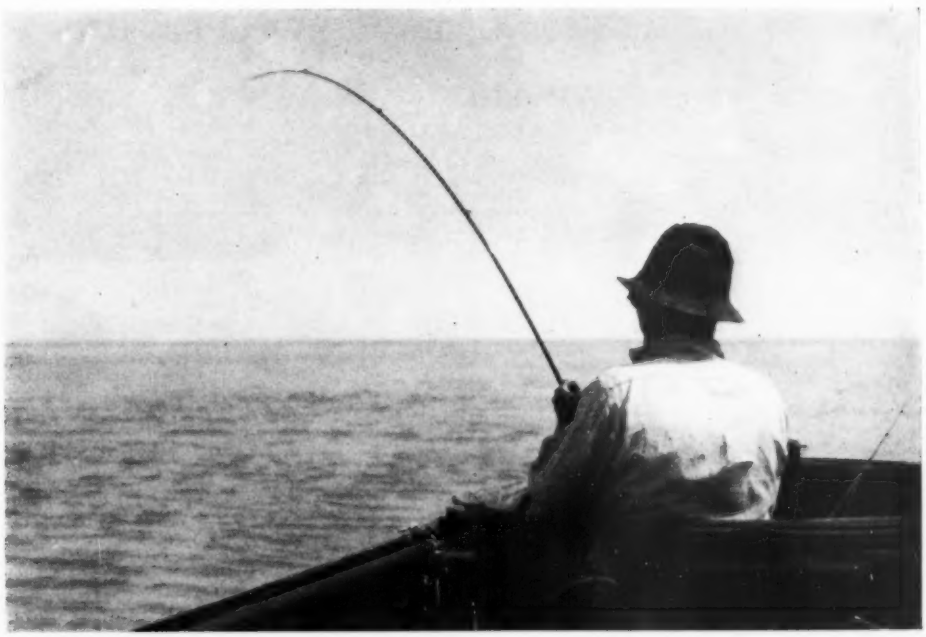
As Florida became more developed and the real estate boom swept down upon the land, I shifted my cruising grounds to the Bahamas, where banks surrounding more than three thousand rocks and cays provide unlimited possibilities for bonefish. At this point I might remark on the spelling of cay which is pronounced there the same as key and means a small island, such as occurs in the Floridian Archipelago or among the Bahamas. The word is evidently derived from the Spanish *cayo* meaning island and in Florida became contracted to "key." Thus the place Key West does not refer to the westerly island of that group, as is naturally supposed, but to the Spanish words *Cayo Huesso*, meaning "Bone Island" the original name of the place.

I have seen thousands of bonefish, and I have caught or been present at the catching of more than three hundred by actual count. While this experience qualifies me to some degree as an observer of their habits, I am just beginning to learn something about them. And I doubt if I shall ever learn enough to qualify as "expert" and certainly never shall I learn as much about them as I should like to.

An acquaintance of mine after catching his first fifteen bonefish, proceeded one evening around the camp dinner

table to give a dissertation on the subject and to point out wherein I was using the wrong tactics. To my reply that the next fifteen bonefish might not bite nor act in the same manner, his derisive laughter forced me to silence. But it so happened that the very next day, with bonefish all around him, and standing ankle deep in the water but twenty feet from me, he was unable to hook a single fish, while I landed five. The explanation was that the fish that day were biting in an entirely different way from those he had caught, but in a way with which I had had some experience. Be prepared for anything in bonefishing, for you never can tell.

Bonefish as a rule (note I say "as a rule," for no set rules can apply to them) begin to feed on the young flood tide. They have been spending the last of the ebb off in deep water, "settled" in holes or in the channels. At the first feel of the incoming tide they start in over the flats in search of food—crabs and various other small crustacea. The angler, anticipating their movements, has poled and dragged his skiff as far into shallow water as possible, and awaits their coming. He should have a goodly supply of bait and quantities of "chum" (ground up bits of fish or conch) with which to hold them in the vicinity. As soon as he observes a school approaching, he should begin to "chum," throwing the ground-up bait astern and in the direction of the on-coming school, but not close enough to frighten them. A bonefish is one of the most wary creatures that swim the seas. The slightest noise, such as a knocking against the side of the boat, or the least movement will scare him to the vanishing point. I have seen the mere shadow of a bird passing over the surface of the water send a school of bonefish in all directions like a flock of frightened quail.



Harry was fast to a large fish

You cast your baited hook amongst the chum and wait. On come the bonefish, passing back and forth across the clear white bottom, picking up the chum with little whirls of sand. One appears to be right over your bait and your heart beats a triple tattoo. A long, green shadow he seems. Now the long upper lobe of his caudal fin flicks the surface. He is burrowing down for your bait. An almost imperceptible tug comes on your line—the slyest of sly pulls. Quick as lightning you flip back your wrist and set the hook. Then the indescribable occurs.

The line leaps from your reel like a living thing, your rod flies forward and describes a semicircle, and you are suddenly aware that you are fast to a quarry with the speed of light—the sportiest thing with fins. Three, four, five, six hundred feet of line streak from your reel and melt into the sea. Your thumb, gloved in its thumb stall, is pressing down with all its might on the ever diminishing spool. The line, dry near the bottom, sets up such a friction that it blisters your thumb even through the woollen cover. You are forced to dip water over your reel. Suddenly his rush ceases and the fish begins threshing about on the surface six or seven hundred feet away. The water there is full of mangrove shoots and you alternately curse and pray for fear he will get tangled up amongst them. Then, as quick as he ran from you, he starts toward you. You reel like a demon. You reel until your wrist aches, but you cannot get a tight line. The bonefish is abreast of your boat, past it, and going in the other direction, and still your slack line sags behind you in a great belly.

"What sport! What a fish!" The exclamation bursts spontaneously from your lips.

"Where is he? Where am I?"

You are bewildered. You get the impression that if you catch this bonefish after all it will only be because he willed it and allowed you to do so.

But stay! His second and third rushes are not quite as far as the first one. He is now in the process of circling your boat; round and round, the line hissing through the water. He can't get very far away, and yet you can't seem to get him much closer. But he is weakening; you can feel it. His circles are narrowing. You can see him clearly now, the hook protruding from the corner of his mouth, his large glassy eye staring malignantly up at you, his tail weaving determinedly back and forth. But you are weakening too. You've lost your hat in the struggle and the hot tropical sun beats down unmercifully on your head; you've blistered your thumb trying to stop him, and wrenched

Our dusky guide chewing up conch to be used as chum

your wrist in your effort to get in line when he ran at you. Who's going to give up first? Then a voice sounds in your ear.

"Try and bring him a little closer the next time around, Boss, and I'll slip the net under him."

It's your native guide, and his voice acts on your senses like an ice pack on a fevered brow. You make the supreme effort, lift the tip of your rod and strain backward, and head first into the net goes your bonefish.

You lift him aboard, extract the hook, and hold him up. Seven pounds of glistening silver! Is it possible that this small fish which resembles a brook sucker has given you all this struggle? You think of the long, lazy days on the Pacific when you've wrestled with swordfish, of colorful deep-blue days on the Gulf Stream when a leaping, twisting demon of a sailfish was trying to describe geometric patterns with your line. But *they* were *big* fish and this one weighs but seven pounds! You're spoiled for all other kinds of fishing. You've joined the ranks of bonefish devotees.

In recalling some of my experiences with these glorious fighters, one or two stand out in my memory above all others. I remember a day of wonderful sunshine without a cloud in the sky. Not a breath of wind ruffled the surface of the water and the flats at low tide lay staring white under the tropical sun. My companion and I had poled our skiff as close inshore as we could before it grounded, but so low was the tide that we were still half a mile from the beach. We anchored the skiff and putting some bait in our pockets, got overboard and waded ashore. Through the flats, which were mainly dry, ran some little sloughs or pockets and in some of these we could see bonefish "settled."

The bonefish occurs in warm seas practically all over the world

The tide started in and suddenly there were bonefish everywhere. In any direction we looked, we could see tails and dorsal fins working in across the banks with the rising water. Bonefish to right of us, bonefish to left of us, behind us, and ahead of us. We counted fourteen schools of incoming bonefish at one time. So still did we stand that they often passed almost at our feet. I became so thrilled and interested in watching them that I forgot to cast. But a shout from my companion apprised me that he was fast to one and I soon followed suit.

How many bonefish we hooked on that tide I can never tell. We caught eleven ranging from four to eight pounds. Once my friend had all his line out and had to run through the water in order to get some of it back. We stayed until the water crept nearly to our waists and quit, not because of it, but because we were figuratively and literally "fished out."

I remember another balmy day in

late February. With two companions and a guide we were drifting over the flats in the latter's sailboat looking for bonefish. The tide had dropped on the banks and we decided to move off to the edge of the channel and fish in deep water. This we accordingly did, and as not much seemed to be biting, I curled up in the furled sail and went to sleep. I was awakened by confused shouts and exclamations from my companions and drowsily rolled over to see what was up.

"Harry has a big bonefish on," they informed me. "Get your line out quick!"

The fish had run out a tremendous amount of line and was now traveling at right angles to the stern. Suddenly a cry of dismay came from Harry. Directly in the line of march of the bonefish, a stake protruded from the water. If the fish fouled that stake, he was sure to break off. And then our dusky guide evinced some of the little intelligence he had ever displayed. Leaping into a small canoe we had tied astern, he paddled as if the fiends were behind him, reached the stake about ten feet ahead of the bonefish, and pulled it up. The day was saved and though Harry was forced later to pass his rod three times around the mast, he landed the fish, which was a magnificent nine-pounder.

I then cast out and almost immediately had a tremendous strike. The line ran out with such speed that my thumb stall quickly burned through to the flesh. I submerged the reel and rod beneath the water in an effort to allay the friction, but I could not stop the fish. Before we could pull up the anchor or untie the canoe to follow him, the fish ran out nearly a thousand feet of line and broke it at the spool! I shall never know how large that fish was but I like to think of him as the world's record. *The* world's record bonefish hangs in the Game Fish Collection of the American Museum of Natural History. It was caught by Burton F. Peek and weighed 13¾ pounds. But there are larger ones than that to be had, and you, dear reader, might be the one to catch him. Who knows?

The bonefish occurs in warm seas probably all over the world. Dr. Robert Cushman Murphy and the writer found them in Ecuador where the natives seemed not to know much about them.

To get the maximum sport from this incomparable game fish, you should use your lightest tackle. The 3–6 class of the Catalina Tuna Club is just right: 6 oz. tip, 6 ft. rod, and 6 thread line; a reel holding two to three hundred yards of line and strong hooks about ⅝ size, and you are equipped. Once you have caught a bonefish, you will never be the same again.

The Zane Grey Game Fish Collection

By FRANCESCA LA MONTE
Assistant in Ichthyology, American Museum

"Lord grant to me to catch a fish
So big that even I
In talking of him to my friends
May never need to lie."

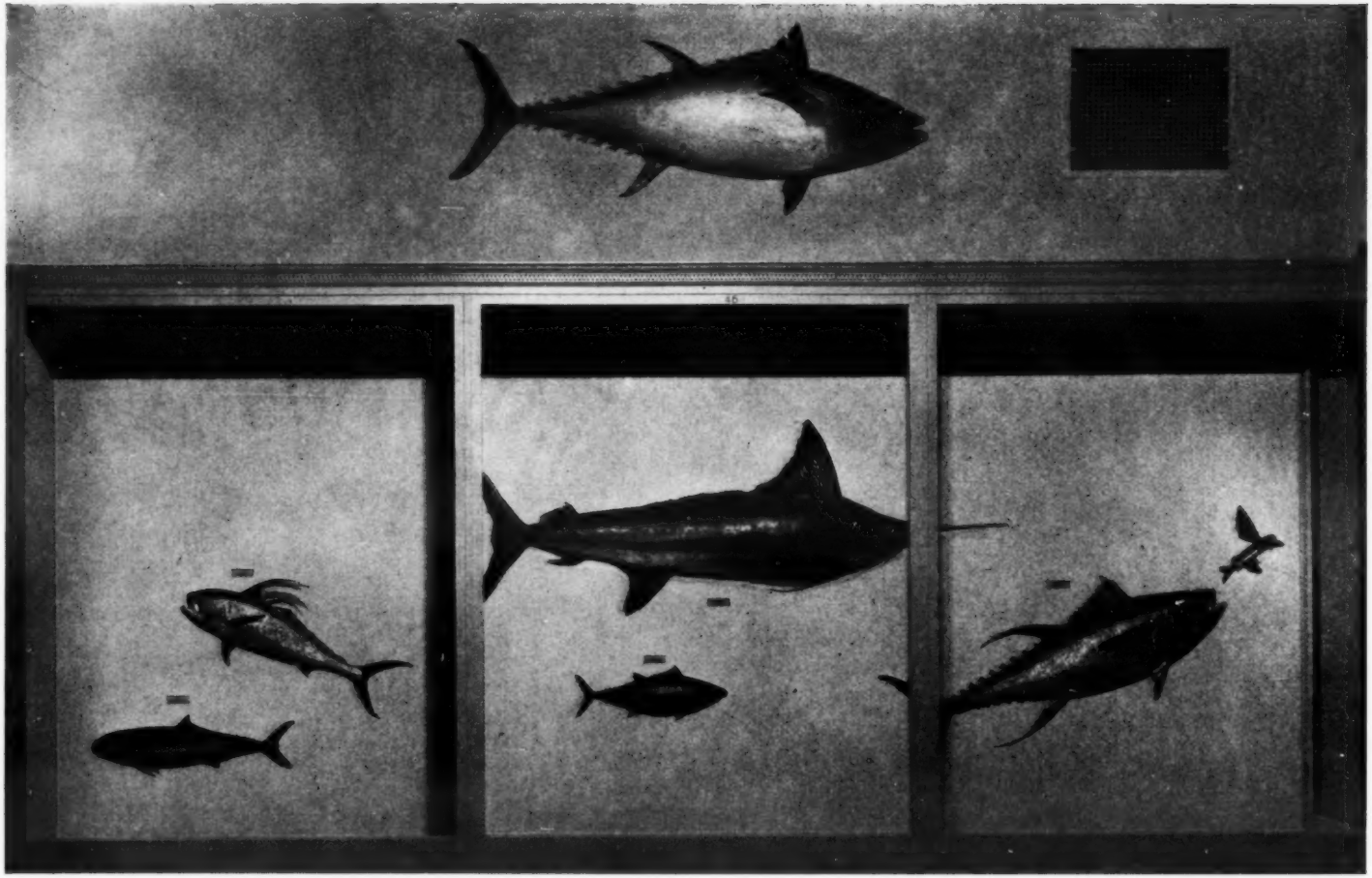
"TO own a beautiful white ship with sails like wings, and to sail into lonely tropic seas"—this was one of Zane Grey's earliest boyhood dreams. How it came true he has told us in his fascinating books of fishing adventures. These are no "fisherman's tales," for in the north end of the Hall of Fishes of the American Museum the visitor may look over many tokens of Mr. Grey's prowess, from the 758 pounds of blue-fin tuna to the huge mass of ocean sunfish, and see for himself the tangible evidence of what the "lonely seas" yielded to this enthusiastic angler. One's first thought is something very like the admiring comment of George Takahashi, a fishing companion of Mr. Grey, as he beheld one of the big catches, "My goodnish graceness! Awful good luck!"

This collection of big game fishes came to the Museum in 1926 as a gift from Mr. Grey, chiefly through the persuasive powers of his friend and our field representative, Van Campen Heilner. Mr. Grey has promised to add to it from time to time some of the trophies of his cruises. As it stands, however, it includes some of the largest, most beautiful, and gamest of fishes. All of them were caught in a sportsman-like way, with "tackle strong enough to subdue the fish, and not to break off a number of hooked fish in an endeavor to catch one on a lighter tackle."

Above the entrance to the proposed Roosevelt Memorial Hall hangs a Pacific sailfish, the prize of a contest in strength and endurance, won only when this lithe, silvery body with its deep-blue sail was hauled lashing and dripping over the side. One can well imagine that other labels, verbal and less scientific than the present one, "Ocean Sunfish, *Mola mola*," were applied during the process of catching the 2000 pounds of slippery flabbiness now flattening its bulk against the background of the case beneath the sailfish. But trophies like these are worth hot suns, aching muscles, and the bitter disappointment caused by the fisherman's will-o'-the-wisp, that "largest one of all"—that always escapes.

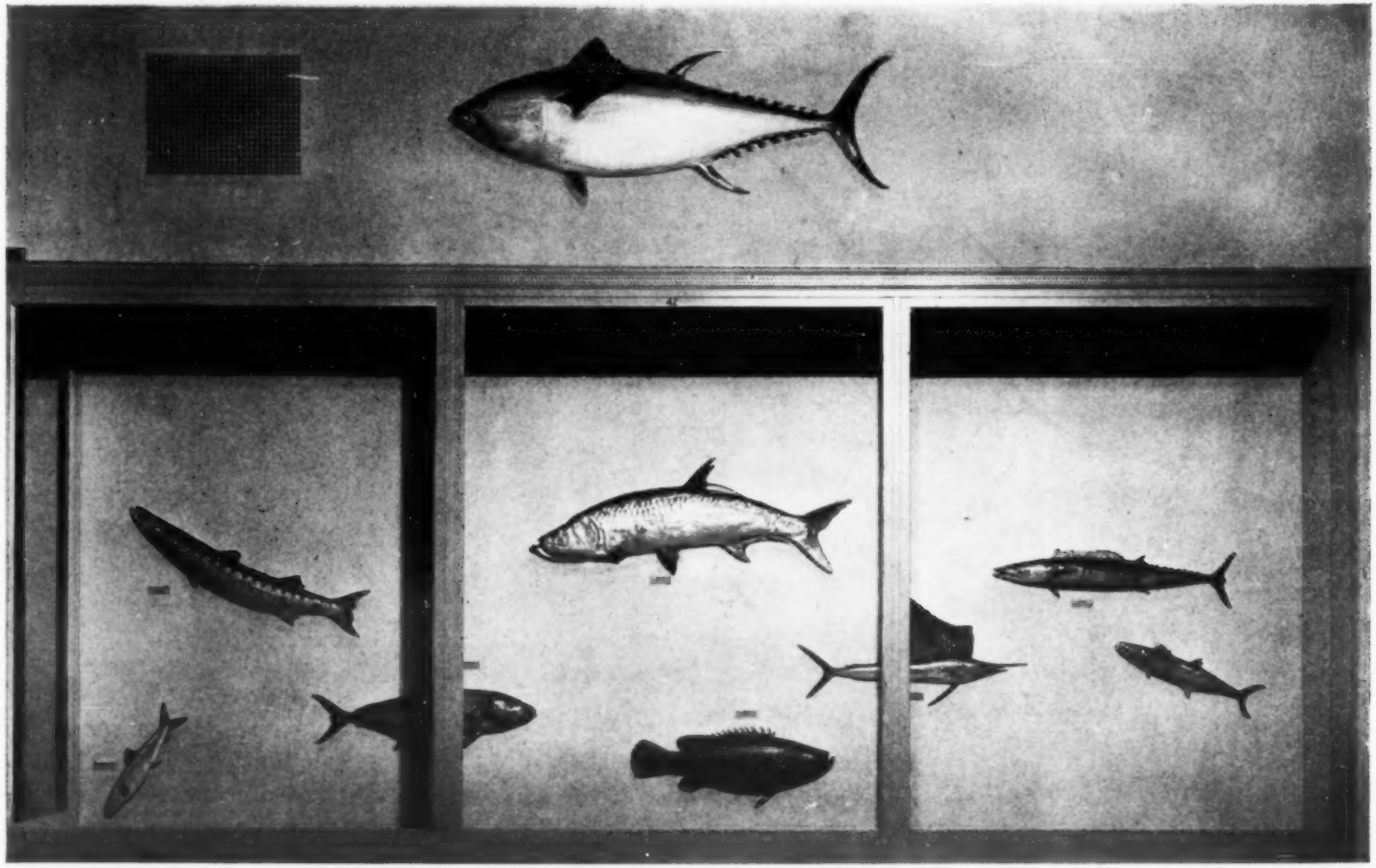
Of course there are some amberjacks, a tarpon, the fierce pike-like barracuda, a wahoo, and a kingfish. But there are very few things to be taken for granted in this collection, certainly not the seemingly innocent bonefish, standing on its head in a feeding position in one corner of a case,—in reality one of the hardest fighting fishes that swims. Nor does every sportsman's list boast a 582-pound broadbill sword-fish, the world record until replaced in 1927 by a 588½-pound catch of Mr. Grey's brother, R. C. Grey.

The glistening silver and blue bodies of two of the most beautiful fish in the collection stand out against the dark, greenish-black of their case neighbor, the black marlin. These are the spectacular rooster fish or pappagallo,



NORTHWEST WALL CASE OF THE ZANE GREY GAME FISH COLLECTION

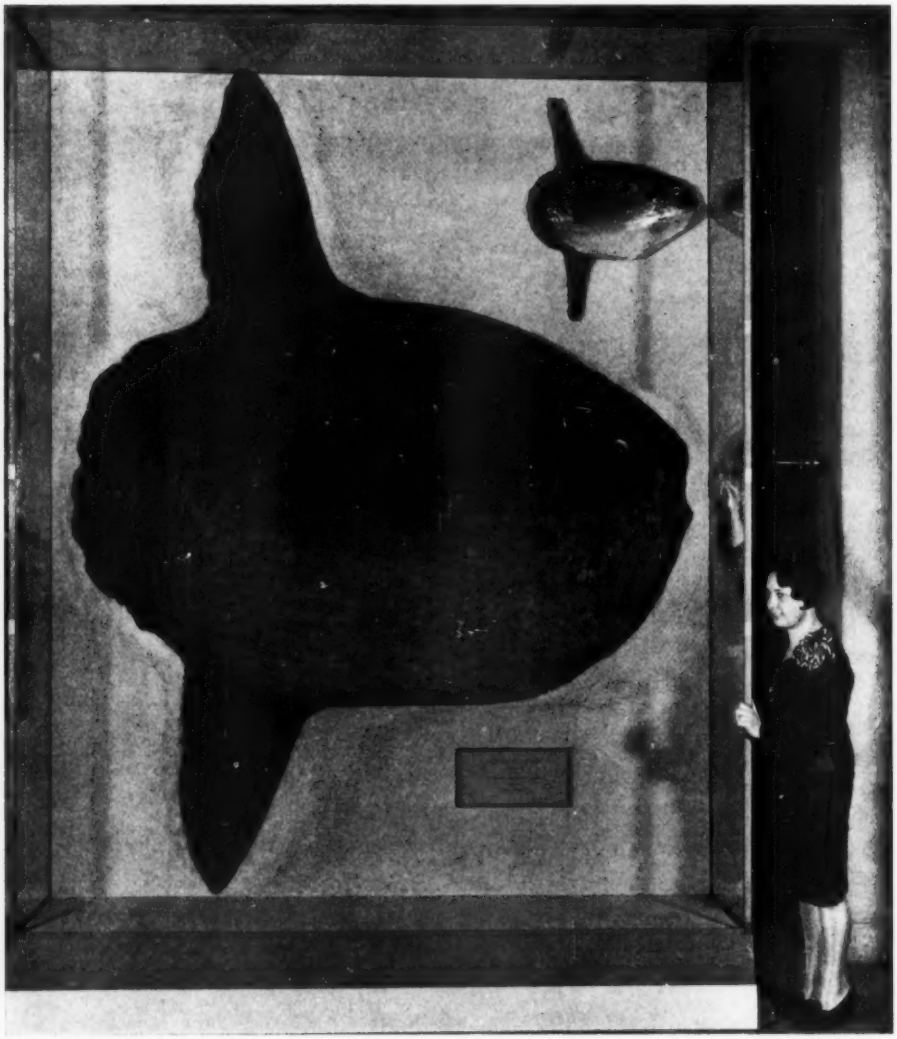
Above this case hangs the 758-pound world record tuna caught by Mr. Grey off Port Medway, Nova Scotia, in 1924



NORTHEAST WALL CASE OF THE ZANE GREY GAME FISH COLLECTION

Particularly noticeable in this case are the bonefish, *Albula vulpes*, and the barracuda, *Sphyræna barracuda*

whose dorsal fin rivals the tail of the proudest rooster, and the yellow fin albacore, *Thunnus macropterus*. Mr. Grey describes the capture of this albacore in one of his books. In its surface run at one time, this fish had 400 yards of line out, and before the end of the fight it dove, taking off half the line with the drag on. When the drag was released, the fish went on down and Mr. Grey had to lift it from a depth of 1300 feet. After it was dragged up to the surface, it took three men to haul it into the launch.



Ocean sunfish (*Mola mola*) caught by Mr. Grey. Weight 2000 pounds

But even more exciting is Zane Grey's vivid account of the capture of the record tuna, which he describes in his recent book, *Tales of Swordfish and Tuna*. Inspired by the example of Captain Laurie Mitchell of Liverpool, Nova Scotia, who held the world record at that time, Zane Grey went

to Nova Scotia to fish for tuna, well equipped with what he calls "a mixture of Florida and California methods." His apparatus consisted of two light skiffs, two-oared, sharp fore and aft, and round as a spoon on the bottom; and a launch 25 feet long, 7½ feet beam, light and strong, with two engines and guaranteed to make eighteen miles an hour and turn round in its own length at full speed. All three boats were furnished with special Catalina revolving chairs with rod sockets. His tackle included Coxe reels, Murphy hickory rods, and Ashaway linen lines. For chum and bait the fishing party used native herring.

The capture of this huge tuna did not take place until Mr. Grey and his friends had been in Nova Scotia for some days, and in spite of disappointments and foggy weather, had made several other big catches of tuna. However, on a certain day when, in answer to the signal of a Nova Scotian fisherman, they threw out bait, Mr. Grey felt that something extraordinary was at the end of the line. Unlike the previous rather temperamental tunas, this fish swam deep, evenly, and somewhat heavily. To the dismay of the anglers, it first ran in among the commercial fishermen's nets, but at last swerved and turned toward open water. Its approach to the reefs of Blue Island, at the risk of cutting the line on the jagged rocks; its turnings; its attempts to head inshore, and Mr. Grey's successful efforts to turn it around toward open water: these form one of the most thrilling stories ever told by an angler. Finally, after the boat had alternately pursued the fish and been towed by it, and Mr. Grey's strength was nearly exhausted by the tremendous muscular effort and skill necessary to keep the tackle from giving under the strain, he succeeded in pulling the fish to the surface and then near enough to lasso and tie it to the stern. The fight had lasted three hours and ten minutes and it took nearly two hours to tow the catch back up the bay to the breakwater. Mr. Grey writes that when the fish was finally hoisted out of the water he could not believe his own eyes. It was even larger than he had anticipated. The native fishermen were amazed to find that the thirty-nine thread line had held and subdued this huge creature 8 feet 8 inches long, 6 feet 4 inches in girth, and weighing 758 pounds.

Perhaps we at the Museum got a faint echo of the breath-taking thrill of these adventures when this great collection arrived and one by one the big packing cases were opened revealing foot after foot of fish, each specimen more startling than the last. And if at times five men struggled to fasten one of the larger fishes to the wall in the Hall of Fishes, what can have been the struggles to capture its resisting, and doubly or triply heavy living body!

The scenes of some of Mr. Grey's cruises, and magnificent views of fish leaping above the surface and fighting on the hook are shown in Mr. Grey's most recent gift to the collection, a series of large colored photographs which will hang on the wall opposite the cases.

Surely many sportsmen and many who are not sportsmen will look at this collection with interest and envy, and recalling that combination of strength, intelligence, fair play, and fun that makes big game fishing a real sport, will heartily agree with Mr. Grey himself that "to catch a fish is not all of fishing."

Carl H. Eigenmann—Ichthyologist[1]
1863-1927

By GEORGE S. MYERS
Leland Stanford University

IN 1877 a thirteen-year old German lad first set foot on the shores of the United States. He grew up in the care of an uncle in Rockport, Indiana. In September, 1882, the boy was admitted to the state university at Bloomington, and entered upon a career which was to take him to a commanding place in American science.

From a recent photograph (1924) of the most distinguished student of the blind cave vertebrates of North America, and the fishes of northern South America

At Indiana University David Starr Jordan occupied the chair of zoölogy, and three years later the presidential position. Those were the days of rigid requirements in the "classics," and young Carl Eigenmann began the study of Latin. But Latin was not to be his work in life, and when Doctor Jordan overturned the old system, Eigenmann chose zoölogy. Under Jordan's guidance he began the study of North American fishes. In 1885 his first paper, a review of the Diodontidæ of North America, appeared. He became an instructor in the department and received his bachelor's degree in zoölogy in 1886.

In the fall of 1886 an opportunity for the principalship of a school in Santa Paula, California, came to Eigenmann through his classmate, Barton Warren Evermann. Eigenmann arrived too late for the position but remained for a while in the state. Going south to San Diego, he there met Miss Rosa Smith, already becoming known by her papers on west coast fishes. Following a short romance, the two were married at San Diego on August 20, 1887. They immediately went north by boat to San Francisco, and thence across the continent to Harvard University. There arrangements had been made for the two ichthyologists to study the immense fish collections made by Louis Agassiz in Brazil many years before, and up to that time practically unworked.

Excepting for a short stay at Wood's Hole in the summer of 1888, the Eigenmanns were at Harvard until December of that year. Jointly they completed, besides several shorter papers, a review of the catfishes of South

[1]Born at Flehingen, Germany, March 9, 1863; died April 24, 1927, at Chula Vista, California.

America, a tremendous undertaking, the final report on which was published by the California Academy of Sciences in 1890.

Returning to California, Eigenmann, who had meanwhile received his master's (1887) and doctor's (1889) degrees from Indiana, was for a time curator of the San Diego Natural History Society, and while there established the San Diego Biological Station. From 1889 to 1891 he was acting curator of fishes in the California Academy of Sciences.

Doctor Jordan and a large part of the Indiana faculty having been called to California for the establishment of Stanford University in 1891, Eigenmann returned to his Alma Mater as professor of zoölogy. Opportunity for ichthyological work was not long in appearing, and in 1892 we find him in the Canadian Northwest, collecting fishes for Albert Günther, keeper of zoölogy in the British Museum, the collections being reported on by the Eigenmanns before shipment to London. After this Eigenmann turned his attention toward studies of variation and of the origin and differentiation of the sex cells in certain of his Pacific Coast fish material. This latter work contributed greatly to his reputation.

Study of the Agassiz collections had whetted an appetite that could not be appeased, however, and though during the nineties little South American material fell into his hands, Eigenmann was merely awaiting an opportunity. It was during this interim that he turned toward the field in which it may be said he placed his name among those of the foremost American men of science.

Possibly the most striking members of the fauna of the limestone country of Southern Indiana and Kentucky are the blind creatures of the underground rivers which traverse the innumerable caves of the region, and of these the blind fishes of the family Amblyopsidæ are most prominent. To the study of these and of the other cave vertebrates Eigenmann turned his attention, and for a period of twelve years a veritable stream of papers by himself and his students issued from the laboratory in Bloomington. The culmination was the publication, in 1909, by the Carnegie Institution of Washington, of *The Cave Vertebrates of America, a Study of Degenerative Evolution*, a magnificent volume and the best known of Eigenmann's works. During the course of these studies Eigenmann visited most of the important caves of Indiana, Kentucky, Arkansas, and Texas, finally making a trip to the caves in Cuba. Plans made for an exploration of the caves at Merida, Yucatan, were never carried out, and the blind fishes there, if they actually exist, have never been made known.

But even in the height of his studies on the blind forms, Eigenmann did not forget the glittering array that inhabited the streams of the southern continent. After 1900, several South American collections fell into Eigenmann's hands, the most important being the extensive materials obtained by Dr. J. D. Anisits in Paraguay. On these, on collections sent by Von Ihering from southern Brazil, and on the South American fishes in the National Museum at Washington, Eigenmann published several papers.

Accidental contact with Dr. W. J. Holland, director of the then recently organized Carnegie Museum at Pittsburgh, started new plans, which later developed into a curatorship of fishes

at the museum, lasting from 1909 until 1918. An opportunity was provided in 1907 for one of Eigenmann's students, John D. Haseman, to travel in South America primarily for ichthyological material. During the three years that Haseman was in the field, he covered more territory than has any single ichthyological expedition before or since, and from the Amazon and most of the large rivers between it and the Paraná, he brought a very nearly unrivalled collection.

Meanwhile, as an accompaniment to the report on the meager materials of the Princeton Patagonia Expeditions, Eigenmann had published an elaborate outline of his theory regarding South American zoögeography. He supported in the main the theory of Von Ihering, viz., the existence at one time of a land mass connecting Africa with parts of the Neotropics, basing his conclusions on the similarity of the African and American ichthyfaunæ.

Soon after finishing his long delayed preliminary report on the characins of the Harvard Museum, Eigenmann himself took the field. On his own funds, backed by promise of somewhat indefinite support by the Carnegie Museum, he went to British Guiana in 1908 on what was to be his most fruitful journey. His principal object was to explore the streams of the Guiana plateau, where he hoped to find the relics of the old Gondwana fauna, and, further, he wanted material for his characin monograph. During a few months in the winter of 1908–1909, Eigenmann made an enormous collection, containing literally hundreds of unknown forms, and making British Guiana for all time one of the classic collecting grounds of Neotropical ichthyology. He did not find the relic forms he had expected on the plateau, but the wealth of material more than made up for the loss. On his return, the Carnegie Museum assumed the expense of the collection and of the publication of the results. The outcome was a magnificent report, *The Fresh-water Fishes of British Guiana*, published in one ponderous volume in 1912, the most important single work in South American ichthyology.

Before the Guiana volume was printed we find Eigenmann again in South America, this time on the Magdalena and Atrato rivers, and the plateau of Bogotá in Colombia, from January to April, 1912. Returning, he almost immediately sent two of his students, Arthur W. Henn and Charles E. Wilson, to western Colombia, later providing for further explorations by Henn in Ecuador. The results of these expeditions were embodied in a report entitled *The Fresh-water Fishes of Northwestern South America*, quite as bulky as the Guiana volume but finally issued in much reduced form by the Carnegie Museum in 1922.

In 1918 Eigenmann again went to South America, this time to the high Andes of Peru and along the coast through Chile. The principal result of this trip, *The Fresh-water Fishes of Chile*, is about to be issued by the National Academy of Sciences. It was on this trip that the strain of the great altitudes broke the indomitable strength of Eigenmann, once before weakened by fever in Colombia, and it is from this time on that we must mark his decline in health.

In 1920 Eigenmann initiated a survey of the fishes of the eastern slopes of the Andes by sending William Ray Allen to the Marañon, Huallaga, and other upper reaches of the Amazon. The material collected by them, although partially identified, remains to

date unreported on. In 1921 the work was carried on by another student, Nathan E. Pearson, in the Beni Basin, and again in 1922 by Pearson in the Andes of Southern Peru and Bolivia. The Beni fishes were worked up by Doctor Pearson and his Andean report is completed. Finally, too late, Eigenmann turned his attention to the lowlands of the mighty Amazon. From 1923 to 1925, Dr. Carl Ternetz, who many years before had collected along the Paraguay for Doctor Anisits and for the British Museum, traveled down the Rio Tocantins, along the Amazon to Manáos, up the Rio Negro and through the Cassiquiare to the Orinoco, and down that stream to Caicará. The collections he made, richer than any brought from South America since those of the Agassiz Expedition and possibly even surpassing them, lie almost untouched in Bloomington.

Throughout this period of extensive South American work, Eigenmann was gradually putting together his great monograph of *The American Characidæ*, by far the largest and most diversified family of the immense Neotropical fish fauna. The first three parts appeared between 1917 and 1921, published by the Museum of Comparative Zoölogy at Harvard. Part four has recently been published, and part five, the last finished by Eigenmann, is in press. Yet but a third of the group is covered. Besides this Eigenmann completed monographs of the Cheirodontinæ, a characin subfamily (1915), the pygidiid catfishes (1918), and the doradid catfishes (1925). Hosts of shorter papers were constantly appearing from his pen.

Eigenmann's scientific work did not prevent him from rendering great service to Indiana University. A list of his students who have attained fame in American zoölogy is sufficient to demonstrate this. In 1895 he founded the Indiana University Biological Station at Turkey Lake (now at Winona Lake) and remained its director until 1920. In 1908 he organized the graduate school and was its dean until his death. Many scientific honors came to him, most notably membership in the National Academy of Sciences—the only man in his state so honored. He was recognized as one of the foremost ichthyologists of the country and indeed we may place him as one of the four greatest of his time.

But one does not think of honors when thinking of Eigenmann. A kindly man with a heart of gold, with sympathy for everyone, jolly, yet stubborn and with a will of iron in carrying out that on which he had set his mind—this was Eigenmann. No professor was ever more beloved by students and colleagues alike; few will be so kindly remembered.

His health broken by his arduous explorations, Eigenmann was taken to his old haunts in Southern California in 1926, but even that mild climate could not revive him. He passed away, after a long illness, at Chula Vista, in San Diego County, April 24, 1927. He lies at rest in San Diego, overlooking the waters he knew so well many years ago.

Eigenmann has passed, and there is no one to fill his place. A great void is left, but his indomitable spirit will live on in the memory of those who knew him. And over those who in the years to come will study the fishes of the dark rivers of Guiana, the mighty flood of the Amazon, and the rivulets and torrents of the Andes from Bogotá to Valdivia, the great and benevolent shadow of Eigenmann will ever fall.

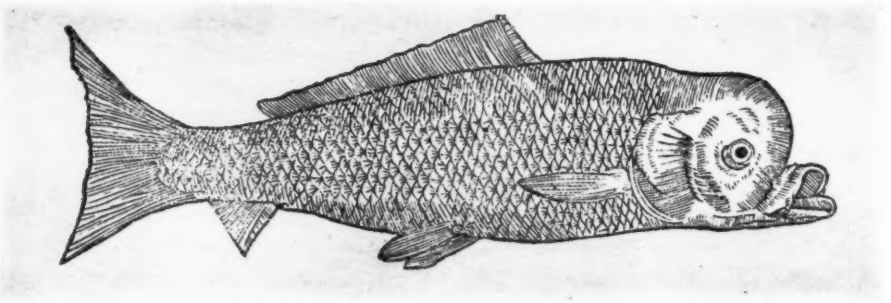


Fig. 1.—The earliest recorded (1554) case of pug-headedness in a fish. Note the steeply rounded forehead and the short, upturned snout with jaws wide open. But for details in the drawing and engraving this might be a modern figure, so accurate is it

Guillaume Rondelet's Pug-headed Carp

THE EARLIEST RECORD—A. D. 1554

By E. W. GUDGER

Bibliographer and Associate in Ichthyology, American Museum

AMONG the numerous and curious malformations in fishes, and one which is universally interesting without exciting the feeling of repugnance commonly aroused by abnormalities in general, is that relating to the shortening of the head and curvature of the snout in fishes. This curious teratological structure, which forms the subject of this note and is shown in Fig. 1, is that designated by the terms "Bulldog-head," "Pug-head," "Lion-head," "Tête de Chien," "Mopskopf" and "Löwenkopf" in the English, French, and German languages respectively.

Years ago in searching through the early literature of ichthyology for other matters, I ran across the case in hand and made a note of it. So far as I know this is the earliest figure and record of this phenomenon, which, imbedded in the old book now to be cited, is practically lost to the science of teratology. So, since it is an interesting thing in itself, and since it is the first record, it seems well to bring it out of its obscurity.

In the year 1554 there appeared at Lyons, in France, a work which laid a solid and sure foundation for the study of fishes. This was a small-sized folio bearing the title *Libri de Piscibus Marinis* and the author was Guillaume Rondelet, regius professor of medicine at Montpellier. Bound with this, bearing the same date, and in effect a second volume of it, is his *Universæ Aquatilium Historiæ Pars Altera*. In this whole work are figured and described 197 marine fishes from the Mediterranean Sea, and 47 from neighboring fresh waters. On page 154 of the *Pars Altera* is the figure and description of the curious fish herein referred to.

Rondelet recognized this as a carp, *Cyprinus* (presumably of the species *carpio*) but, as he had never seen such a fish before, he thought it a new and unusual form or species and accordingly he made the heading for his Chapter VII read "De Cyprini mira specie"—"concerning a carp of an unusual species." Of it he says—"I ought not and indeed cannot pass by in silence a strange species of *Cyprinus*

which was purchased alive in a fish market in Lyons." He then goes on to show that his fish is undoubtedly a carp, but is very different from the others which he had studied and figured. He compares its head to that of a dolphin (the mammal, not the fish), and says that it is accurately shown in the figure.

The figure is indeed an admirable one, and worthy of being brought to the attention of the scientific world. It speaks well for Rondelet's accuracy of observation and for the skill with which his artist and engraver portrayed the actual fish. In all but the details it might be taken for a modern figure.

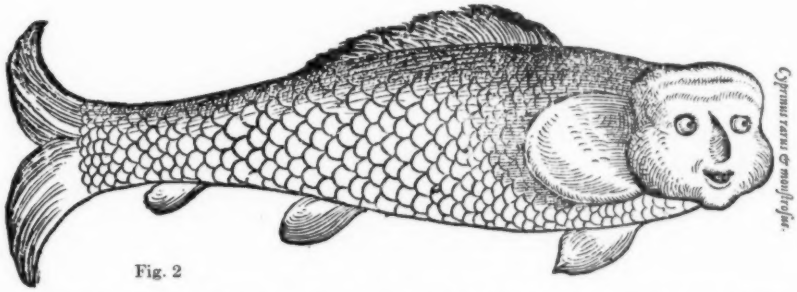


Fig. 2

Gesner's (1558) monstrous carp. Apparently this is a case of round-headedness rather than pug-headedness. The artist has taken great liberties with his subject and, instead of showing the fish in lateral view, has drawn the body in side view, but has figured the head as if turned at a right angle to the body as in an animal having a neck

Conrad Gesner, the universal naturalist of Zurich, Zwitzerland, in Liber IIII ("De Piscium and Aquatilium Animantium Natura") of his encyclopedic *Historia Animalium* (Tiguri, 1558) quotes Rondelet but does not give his figure, and then proceeds to confuse matters very much. It seems that he had data for four specimens of similar abnormal carps—one taken in October, 1545, from a small river (the Eirs) near Retz in Austria: another captured in Lake Constance near Retz in November, 1545; a third taken in 1546 in the province of Brandenburg; and a fourth taken in February, 1554, and kept alive for nine days in a fishpond. Of these fishes, two specimens (numbers 1 and 4) actually came into his hands, presumably as dried skins (since that was about the only method of preservation in those days) and probably stuffed. From the fact that numbers 1 and 2 were both taken near a city called Retz and in the same year (1545) and but one month apart, one might conjecture that the two fish might be one, but the names of the donors are given and plainly indicate that there were two separate fish.

Furthermore, Gesner had sent to him paintings of fish numbers 1 and 2. Which of these he reproduced cannot be definitely determined. Possibly he had a figure drawn which embodied features of both paintings and possibly of the (dried) fishes also. This figure (my number 2) is a veritable monstrosity. The fins and especially the tail are poorly drawn As to the head, one hardly knows what to say. It is conceivable that it is a bulldog-fish which instead of being drawn in profile, is figured as having the head turned quartering to the right. It is also possible that Gesner is portraying here what is called "round-headedness" in

fishes which is defined by the best authority as a condition in which "the skull is more or less sharply humped upward in the frontal region so as to present a somewhat prominent brow or forehead . . . while] the lower jaw does not project markedly beyond the upper one." In any case, unlike Rondelet's accurate figure, Gesner's portrayal has no scientific value, as may be seen on inspection of Fig. 2.

A brief explanation is in order as to the cause of pug-headedness. It seems probable that this deformation arises in the course of development from some germinal defect—which is just another way of saying that we do not really know the cause. Strange to say this abnormality has been found to be inherited in some fish in the third and fourth generations. One experimenter by breeding two "puggy" fish obtained normal young. On interbreeding two of these normal fish, "puggy" grandchildren were obtained. Similar interbreeding of normal fish of the third generation gave a number of fish resembling their "puggy" great-grand parents. However, so far as I know, these experiments have never been duplicated.

NOTES

CHARLES W. MEAD
1845-1928

On February 3, 1928, the American Museum suffered a severe loss in the death of Charles W. Mead, honorary curator of Peruvian archæology since his retirement in 1925. Mr. Mead entered the service of the Museum as cataloguer in the department of anthropology in 1897, but later, because of his detailed knowledge of South American archæological collections, particularly those from Peru, was placed in charge of these and remained so until his death. The scientific and administrative staffs of the Museum, at a special meeting, held February 4, 1928, expressed their sense of loss in the following resolution:

RESOLUTION

The members of the Scientific and Administrative Staffs and of the Department of Anthropology of the American Museum of Natural History, here assembled to note the passing of Charles Williams Mead, Honorary Curator of Peruvian Archæology and connected with the Museum for more than thirty years, wish to record our appreciation of his sterling personal qualities and tireless and cheerful devotion to his duties.

We also wish to extend to Mrs. Mead, his wife for sixty years, to his daughters and to his grandchildren our deep sympathy.

ASTRONOMY

THE AMATEUR ASTRONOMERS ASSOCIATION is gaining steadily in membership and judging by the attendance at the meetings, the programs are proving of great popular interest.

Mr. David B. Pickering, president of the American Association of Variable Star Observers, who spoke January 19, on "The Romance of Variable Stars," stressed the fact that the professional astronomer needs all the latent power in associations like the Amateur Astronomers Association, and especially the observations of the amateur who is studying the variable stars.

At the meeting held on February 2, prizes were awarded to the winners of the Garrett P. Serviss astronomical competition conducted by the *New York Evening Journal*. Dr. E. E. Free, consulting engineer, Dr. Palmer H. Graham, professor of astronomy in New York University, and Dr. Clyde Fisher, curator of astronomy in the American Museum of Natural History were the judges in this competition.

An impressive ceremony took place when Garrett P. Serviss was made first honorary member of the Society. This was especially appropriate since, through his books and lectures, Mr. Serviss has done more in the last forty years to popularize astronomy in America than anyone else.

Prof. Anne S. Young, of Mount Holyoke College Observatory and Member of the Advisory Council of the Amateur Astronomers Association, gave a very interesting talk February 16, on her recent visit to England to see the eclipse of the sun. This was the fourth eclipse she had observed.

On March 16, Prof. Leon Campbell of

Harvard College Observatory will speak before the Association on "What the Amateur Astronomer Can Do."

At the April meeting, Professor Frank Schlesinger of Yale College Observatory will discuss "Life on Mars."

In May, Prof. J. Ernest G. Yalden will talk on "Astronomy in Navigation."

PLANETARIUM IN ROME

"Rome was not built in a day," and Mussolini evidently felt that it is not yet complete, for he has just signed a contract for the establishment of a Zeiss Projection Planetarium in the Eternal City.

Americans may exult over the big refracting telescope at the Yerkes Observatory and the giant Hooker reflecting telescope at Mt. Wilson Observatory, and they may justly take pride in the significant additions to our knowledge gained by our research astronomers by means of these and other equally important modern apparatus, but it should be a matter of chagrin for Americans to realize that they are following the lead of Europeans in the matter of popular education in Astronomy.

Previous to Rome, Moscow had already contracted for a planetarium, and one is already in operation in Vienna, and negotiations are being carried on in several other cities with a view to the installation of this epoch-making apparatus.

In Germany, where this marvelous technical achievement was brought forth, there are thirteen of these instruments in operation. They are located at Munich, Jena, Barmen, Dresden, Düsseldorf, Leipzig, Mannheim, Nuremberg, Aachen, Stuttgart, Hamburg, Hannover, and Berlin.

At Hannover, the dome in which the planetarium is installed is the crown of the administration and office building of the *Hannoverscher Anzeiger*. Independent stairways, and an express elevator holding twenty persons, afford access to the planetarium on the top of this tall building. Especial mention is made of this because it is the only planetarium yet built which involves the same problems as the one planned for the American Museum of Natural History, that is, in which the planetarium will be located on the top of a five-story building, the proposed Hall of Astronomy.

Since returning from my astronomical mission to Europe in 1925, it has been a source of great satisfaction to have my enthusiastic report concerning the planetarium corroborated by professional astronomers.

Professor Max Wolf, director of the Observatory at Heidelberg-Königsstuhl, writes:

> It is this knowledge [of the night sky] which the Zeiss Planetarium imparts; hence the reason of its great success. . . . For me it was certainly one of the greatest pleasures of my life when I saw the Zeiss heavens move above me for the first time. The Planetarium reproduced the aspect of the heavens with amazing fidelity. . . .
>
> The Zeiss Planetarium has, therefore, grown to be a popular means of education almost without parallel in any branch of learning within the history of man; . . .

Professor Elis Strömgren, director of the observatory in Copenhagen, says:

> He who writes these lines certainly does not doubt that Copenhagen will sometime, sooner or later, acquire its own planetarium. . . . never has a means of entertainment been provided which is so instructive as this, never one which is so fascinating, never one which has such general appeal. It is a school, a theatre, a cinema in one; a schoolroom under the vault of heaven, a drama with celestial bodies as actors.

Dr. R. G. Aitken, associate director of the Lick Observatory, writes:

> The Zeiss Planetarium is the most remarkable instrument that has ever been devised to exhibit impressively, and with the illusion of reality, the motions of the heavenly bodies and the phenomena which result from these motions.

In support of my prophecy as to the number of persons that would be attracted to our planetarium, let me state that in one year the planetarium in Berlin has had more than 450,000 paid visitors.—CLYDE FISHER.

THE EXECUTIVE COMMITTEE OF THE AMERICAN MUSEUM'S BOARD OF TRUSTEES at their last meeting approved the plan of erecting the planetarium upon the ground in the northeast court of Manhattan Square, from which place it could be hoisted to the top of the Hall of Astronomy when that is built.

CENTRAL ASIATIC EXPEDITIONS

PRESIDENT HENRY FAIRFIELD OSBORN gave a farewell luncheon February 23 in the Members Room of the Museum to Walter Granger, palæontologist, Leslie E. Spock, geologist, and Albert Thomson, preparator, members of the staff of the Central Asiatic Expeditions, who were scheduled to leave New York on the following day for San Francisco. Other guests were, Director George H. Sherwood, Prof. Charles P. Berkey, Prof. W.

K. Gregory, Mr. N. C. Nelson, Mr. Barnum Brown, Dr. C. C. Mook, Dr. G. G. Simpson, and Dr. Chester A. Reeds. Following the luncheon an hour was spent in a round table discussion of the past and present work of the expeditions. Professor Gregory paid special tribute to Mr. Granger for his excellent collections in the Orient during 1922, 1923, 1925, and 1926, and for his able assistance to Professor Osborn in the preparation of the Titanothere monograph, page proof of which had just arrived. Following the address by Director Sherwood, Professor Berkey, chief geologist, and Mr. Nelson, archæologist of the 1925 expedition, recounted past experiences and gave timely hints to the new members of the staff.

Before sailing from San Francisco on March 2, Mr. James B. Shackelford, photographer, joined Mr. Granger's party. A week later Mr. Alonzo W. Pond, archæologist of the expedition, sailed from Seattle to meet the party at the expedition's headquarters in Peking. Dr. R. C. Andrews, leader of the expedition, is planning to start for the Desert of Mongolia by mid-April.

Dr. Chester A. Reeds, editor of a large number of the Central Asiatic Expeditions' publications, has prepared a circular concerning the seventy-nine preliminary papers and the "Geology of Mongolia," Volume II, *Natural History of Central Asia*, the first to appear of the series of twelve final report volumes. This circular will be sent gratis upon request.—C. A. R.

CONSERVATION

Smoky Mountain National Park Assured.—The most important recent event in the field of conservation is the gift of nearly $5,000,000 to the Great Smoky Mountain Park fund by the Laura Spelman Rockefeller Memorial. This sum, with the money already raised by subscription and an approximate sum by the State and Federal governments, will permit transforming the area from a National Park on paper to a park in reality, and will result in calling a halt on the logging operations that were wiping out the forests whose preservation was the chief reason for making the region a park. The new National Park will include about 700,000 acres. It is said that 300,000 of these acres are virgin forests, the last extensive area of that kind anywhere in the eastern United States. It will also be of importance as a game preserve, especially for the wild turkey, black bear, deer, and elk.

Yellowstone Park Enlargement.—Recent attempts to enlarge the Yellowstone Park, a project that is particularly important in order to provide winter range for the game, especially the elk, driven out of the present park in winter by the deep snows and lack of food, have invariably been complicated by efforts to open up parts of the present park to exploitation. The bill, H.R. 17, introduced by Representative Addison T. Smith of Idaho, in the early part of the present session of Congress, has aroused great opposition. the Bichler meadows in the southwest part of the park being only one of several parts of the park that the passage of the bill could open up to lumbering or reservoir building.

As a result of these protests, two bills, S.2570 and S.2571, have been introduced by Senator Peter Norbeck of South Dakota, as a substitute for bill H.R. 17, and should receive the endorsement of all conservationists since, while adding most of the area the latter bill would include, they preserve intact the present park boundaries. These boundaries have been maintained inviolate for more than fifty years, ever since the park was established, and no proof of any public necessity for breaking them down has been presented by anyone.

Save the Calaveras Groves of Big Trees.—Appeals to the generosity of the public for contributions for saving areas of especial scenic importance have been so numerous of late that there is danger that some of them will fail unless people can be aroused to a realization that these places must be acquired and protected at once if they are to be saved at all.

A new and very important conservation project is the effort of the Calaveras Grove Association (Harriet West Jackson, President, Stockton, California) to save from the lumbermen the famous Calaveras Groves of big trees, which are situated on the west slope of the Sierra Nevada range a little north of the latitude of San Francisco.

This property is in private ownership and a start was recently made to log off the timber. Only its acquirement by the state for a park can save the big trees. Besides two distinct groves of big sequoias a short distance apart, this tract contains some of the finest sugar pine forest still in existence, the saving of which is especially important, owing to the destruction of the sugar pines in the Yosemite National Park. The estimated cost of the

property is $900,000. It is expected that certain state funds will become available to pay part of the cost of obtaining it for a state park, but under the law an amount equal to that contributed by the state must be raised by donation or otherwise. The above society has been incorporated to raise the sum necessary, and merits the heartiest cooperation of those who can afford to help it in any way, large or small.

DEDICATION OF THE NEW SCHOOL SERVICE BUILDING

An impressive ceremony, planned and carried through by Mr. G. H. Sherwood, director of the Museum, and Dr. Clyde Fisher, curator of visual instruction, marked the dedication of the new School Service Building, and the unveiling of the William Henry Maxwell Memorial at the American Museum on January 17. Leaders of education of city, state, and nation united in praising the work of the Museum along educational lines. President Henry Fairfield Osborn presided and opened the program with an address on "The American Museum in City and State." The formal transfer of the School Service Building to the Museum was then made by the Hon. Walter R. Herrick, representing the Mayor of New York City. After President Osborn had accepted the transfer in the name of the American Museum, he invited Dr. John H. Finley, former Commissioner of Education of New York State, to speak on the life and achievements of William Henry Maxwell, first Superintendent of Schools of New York City. Mr. John Greene, president of the Maxwell Memorial Association, then presented the gift of that Association to the School Service Building. After President Osborn had accepted this gift, the auditorium was darkened for a moment. Then a dim light, which brightened gradually, revealed a striking statue of William Henry Maxwell. This statue, of which Charles E. Tefft was the sculptor, is cast in a beautiful green bronze, and is a handsome addition to the School Service Building.

Other addresses were made as follows: Museums as National Assets, Dr. John J. Tigert; The Museum and the State, Dr. Charles C. Adams; The Museum and the City Schools, Dr. William J. O'Shea; The American Museum's School Service, George H. Sherwood.

Music was furnished by the Dewitt Clinton High School Orchestra assisted by the Euterpe Club of Washington Irving High School.

At the close of the program the guests inspected the new School Service Building.

EDUCATION

Dr. John J. Tigert, United States Commissioner of Education, pays tribute to the Museum's educational work in his February News Bulletin. He says in part,

Museums As an Aid to Education

The City of New York has recently built and dedicated to the service of public education a School Service Building. This building is a four-story and basement structure, 160 feet long and 90 feet wide. It is especially designed and equipped to house the school service unit of the American Museum of Natural History, and to facilitate the various educational activities which have been successfully carried on by it for many years.

New York has demonstrated that the Museum can be utilized effectively as an aid to education. Not only are pupils sent to the Museum for first-hand experience in this treasure house of knowledge, but an extension and messenger service has been maintained which brings to the various classrooms of this great city the nature-study collections, the slides, the films, the picture and library exhibits which the teacher may need to vitalize and objectify her teaching.

These extra-mural activities of the Museum have increased rapidly, and they suggest a way of making available to the children of our farms and other isolated sections the enriched education made possible by experience with museum collections. If State departments of education should develop large central museums the various materials and exhibits could be sent out from them to the various schools when needed. There is a great need of teaching in terms of things rather than abstractions and the wealth of the museum could be made available to all instead of being restricted to the few if the example of this great city museum were followed. The museum is assuming a rôle in public education similar in importance to that of the library and, as education becomes more and more a matter of real things and life situations, its use for educational purposes increases.

The Department of Superintendence of the National Educational Association held its midwinter meeting February 25–March 3 in Boston. Mrs. Grace Fisher Ramsey, associate curator of the department of public education, represented the Museum at this conference. On February 25 Mrs. Ramsey attended the annual meeting of the National Council of Supervisors of Nature Study and School Gardening, and on the following Monday and Tuesday the sessions of the National Academy of Visual Instruction, where she spoke on the supple-

mentary relationship of the educational work of the Museum to that of the schools.

MAMMALS

THE STOLL-MCCRACKEN SIBERIAN-ARCTIC EXPEDITION OF THE AMERICAN MUSEUM.—On February 11 the schooner "Effie Morrissey," under command of Capt. Robert A. Bartlett, left New York for Seattle by way of the Panama Canal. The Museum is represented by H. E. Anthony, curator of the department of mammals, who is in charge of the scientific party, E. M. Weyer of the department of anthropology, F. L. Jaques and A. Johnston of the department of preparation.

The expedition is financed by Mr. Charles H. Stoll of New York City. Mr. Harold McCracken, the leader, has had considerable experience in Alaska and spent several years there engaged in photography and the collection of data for lectures and writing. Part of the personnel will join the "Morrissey" at Prince Rupert, British Columbia, about the middle of April, and the last of the party will go aboard at some point on the Alaskan peninsula.

The purpose of the expedition is to secure specimens of mammals, birds, fishes, reptiles, insects, plants, and archaeological material at various points in Alaska and Siberia. Among the hoped for achievements are the securing of groups of the Pacific walrus, sea otter, ribbon seal, sea birds from one of the islands in the Bering Sea, a bowhead whale, and possibly a hairy mammoth frozen in the ice. In addition to exhibition material, it is expected that large and valuable collections will be made of specimens for the study series. It is hoped that the archaeological investigations will shed some light on the human migrations back and forth across the Aleutian chain, and any important clues bearing on this question will be investigated.

After visiting several collecting sites in Alaskan waters, the expedition plans to move over to the Siberian side and make collections from Kamchatka northward through Bering Strait and west at least as far as the mouth of the Kolyma River and possibly even to the mouth of the Lena River. The field selected by the expedition is a very rich one and but poorly represented in American museums.

Throughout the entire cruise special attention will be devoted to the collecting of porpoises, dolphins, and the smaller cetaceans, since these northern waters are a favorite haunt of these marine mammals, and the schooner will be well equipped for taking care of this type of material.

The expedition plans to return about the first of November.

THE VERNAY-FAUNTHORPE EXPEDITION.—Arthur S. Vernay who, accompanied by Col. J. C. Faunthorpe, for some time has been making collections of rare specimens of Asiatic mammals for the American Museum and who sailed in November for Burma to secure, in particular, the *Rhinoceros sondaicus*, a small, one-horned species which is almost extinct, has forwarded a cable to the Museum announcing that the party has been unable to locate any specimens and it is thought the animal is extinct. He further stated that all game was very scarce and the jungles almost impenetrable.

Messrs. Albert Butler and Clarence Rosenkranz, from the department of preparation of the Museum, who accompanied the expedition as far as India to secure accessories for groups and color sketches for backgrounds, have been most successful. The members of the party will soon return to New York.

THE LEE GARNETT DAY RORAIMA EXPEDITION.—The members of the expedition to Mount Roraima which was financed by Mr. Lee Garnett Day have recently returned. Mr. G. H. H. Tate, of the Museum's department of mammalogy, in describing his experiences, says:

Alas, the reputation created for that unusual mountain by Sir Arthur Conan Doyle in his *Lost World* is utterly ruined. Not a trace of a dinosaur exists; even their distant relatives, the lizards, shun the inhospitable plateau.

More than eight thousand feet above sea level, mist-bound, and lashed by cold rains almost the year round, Roraima's twenty-odd square miles of rocky waste cannot reasonably be expected to maintain a teeming fauna of Brontosauri and pterodactyls. In truth, the scant, wiry plant-growth of the rifts and hollows seems barely sufficient to feed the one hundred and twenty kinds of living creatures —most of them insects—encountered by us.

The mist is most exasperating. A rent in the fog lets through a few rays of sunlight. Ensues a frenzied scramble over slippery rocks lugging "Graflex" or "movie" camera toward some much desired subject. You may even succeed in setting up your machine before the clammy, gray blanket blots out the scene once more.

One never escapes from that just-around-the-corner feeling. Even though one is fully aware that no startlingly spectacular creatures can possibly exist on the mountain, the feeling persists that perhaps just beyond. . . .

The fascination of invading a tableland,

utterly unexplored except close to the place of ascent took hold of us. And indeed we made most interesting discoveries there: perfectly preserved ripple marks in the sandstone; a probably new flycatcher; an undoubtedly new burrowing mouse; a St. John's-wort apparently confined to the great crevass at the center of the mountain-top; and, unquestionably, a number of undescribed forms among the invertebrates.

The most important part of the vertebrate material had been expected from the cloud forests at the foot of the precipice. We obtained representative collections from this zone only with great difficulty for, a few years before, forest fires had swept the slopes, leaving but a few wooded patches in the deeper gullies. A considerable portion of our birds and mammals we found at the southeastern foot of the mountain.

The journey northward from the Amazon had not been without incident. Mr. Carter while in quest of birds caught sight of a jaguar feasting on a freshly killed colt. He stalked the animal, and from behind a tree only some fifteen feet away killed it with buck-shot.

More than one specimen of the giant anteater were taken by members of the expedition. These great creatures have immensely powerful muscles, and are armed with large curved claws with which if the need arises they can do much damage. When trying to escape they achieve a clumsy gallop that often tests the hunter's running powers to the utmost.

One night I had the unforgettable experience, while passing along a narrow forest trail, of almost stepping on a bushmaster four feet seven inches long. The dry rustle of his vibrating tail first warned me of his presence. Behind me, on the very spot where I had stepped a few seconds before, now lay a mound of snake half a foot high.

Equally memorable, and the reverse of disagreeable, was our association with General Candido Mariano Rondon, a prominent figure in the field of Brazilian exploration. The General, with his staff, was conducting a separate expedition to the northern frontier. We arranged to join forces for the northward march, and thus my companions and I enjoyed the society and counsel of General Rondon and his officers for many days.

The collections brought back to New York comprise more than 1250 birds, 550 mammals, 500 sheets of dried plants, over 100 reptiles (the South American rattlesnake, *C. terrificus*, is quite abundant on the savannas about Roraima), amphibia, and fishes, several hundreds of insects and other invertebrates, representative rock specimens, moving pictures, and numerous photographs.

In addition to the new forms already mentioned, the collection includes a dozen specimens of the rare honeycreeper, *Diglossa major*, nearly fifty examples of a mouse, only one specimen of which has ever been taken before, the graceful Roraima pitcher-plant, giant purple *Utricularias* peculiar to Mount Roraima, and many other forms of animal and plant life either very rare or as yet undescribed.

INSECT LIFE

Curator Frank E. Lutz attended the meetings of the American Association for the Advancement of Science and its affiliated societies at Nashville as a delegate from the Museum. He is a representative of the American Society of Zoologists on the council of the American Association, and was president at these meetings of the Entomological Society of America.

Following the Nashville meetings Curator Lutz went to Brownsville, Texas, where he was joined by Research Associate Schwarz for a short study of the insect life there in midwinter. Brownsville, at the southernmost tip of Texas, is "subtropical" and is the northern limit of a number of animals and plants whose center of abundance is farther south. One of the most spectacular finds was an exceptionally large nest of a wasp that does the unwasplike thing of storing honey. It is the tropical *Nectarina lecheguana*, apparently occurring nowhere else in the United States and known to the Brownsville people as the "Mexican stingless bee." It is not strictly Mexican but ranges at least to the central part of South America; it is not a bee; and two of them demonstrated to the complete satisfaction of Doctor Lutz that they were quite able to sting if sufficiently urged.

REPTILES

New Habitat Group of the Dragon Lizards of Komodo.—On February 1 there was formally opened to the public one of the largest and most spectacular habitat groups in the new reptile hall. The group portrays a dramatic incident in the life of the now famous "Dragon Lizards of Komodo." A pair of the lizards, feeding on a wild-boar kill in one of the sunny valleys of Komodo Island in the Dutch East Indies, are interrupted in their meal by a third lizard of large size which starts forth from a near-by jungle to dispute ownership with the others. A fourth saurian peers out from its den under the roots of a tree, as if wondering whether to take part in the approaching battle.

The specimens and materials for this group were obtained by an expedition under the leadership of Mr. W. Douglas Burden. The dragon lizard, *Varanus komodoensis*, is a large monitor of the family Varanidæ. It is closely related to certain monitor lizards of Australia, especially to giant forms known only as fossils from the Pleistocene of that continent. It is

believed that the latter reached fifteen or more feet in length. *Varanus komodoensis* does not exceed ten feet, but large specimens may weigh more than 250 pounds. It is, therefore, very much heavier than any other living lizard.

The beasts mounted in this very realistic group have a superficial resemblance to dinosaurs. The exhibit includes a large chart showing the relationships of the lizards to the other groups of back-boned animals, including the dinosaurs and man. The chart is illustrated with many sketches of the extinct forms. The latter, arranged as they are beside the Komodo group, become much more like living creatures in the mind of the Museum visitor, who usually thinks of them only as skeletons.

A third part of the Komodo exhibit is an automatic motion-picture projector which depicts on a screen beside the group five of the most exciting minutes in the capture of the giant lizards. This picture was made by Mr. and Mrs. Burden and has become so popular since the exhibition was opened that it has been found necessary to run it only at stated intervals. The group, the chart, and the motion picture show in detail what the giant lizards are, where and how they lived, and in what way they were captured. The exhibit therefore appeals to the student and to the sportsman, as well as to the average visitor.

The group was prepared in the Museum's department of preparation under the direction of Mr. James L. Clark. The lizards were mounted by Mr. J. W. Hope, the background was painted by Mr. A. A. Jansson, and the accessories were prepared by Mr. Paul Niemeyer.

SCIENCE OF MAN

MR. GEORGE D. PRATT has presented to the department of anthropology two prehistoric pieces of pottery from Japan. One of these is a head of a large mortuary statuette, such as are found in prehistoric burial mounds in many parts of Japan. Models of these tombs are on exhibition in the Japanese section where these two pieces of pottery will also be placed.

BOOK REVIEW

Dragon Lizards of Komodo.[1]— Running the eye along a map of the East India Islands, one finds between Flores and Sumbawa a little speck that is labelled Komodo. Of late years this speck has come into prominence as the home of the "dragon lizard," the largest of living lizards. For many years the existence of these animals was unsuspected; the island was uninhabited, visited only occasionally by pearl fishers, and it was through these that eventually came rumors of the presence of huge and terrible creatures, doubtless dragons.

Instigated by these rumors, a Dutch naturalist, Dr. P. A. Ouwens, sent collectors to the island, who returned with a few specimens which he described under the name of *Varanus komodoensis*.

Then came the world war and everything else was forgotten, even the dragon lizards, but after quiet settled upon earth temporarily, a German sportsman visited the island and shot a specimen said to have measured 21 feet in length. In view of subsequent events, Mr. Akeley suggested that this lizard was probably measured after the method customarily used on sharks and crocodiles, and that the specimen was 10 feet 6 inches from nose to tail and 10 feet 6 inches from tail to nose—21 feet in all. Even 10 feet 6 inches seems to have been rather a strain on the animals. It is a well-known fact that no matter how big a beast is, he will usually shrink before the application of a two-foot rule, and out of the fifty-four specimens that came under the observation of R. E. Dunn, the herpetologist of the expedition, only one reached a length of 9 feet. But a lizard 9 feet long, weighing 200 to 250 pounds, with steel-like muscles, sharp claws, and powerful jaws, is no mean antagonist.

Naturally examples of these rare and monstrous reptiles were greatly desired by museums, but who was the Saint George to go in quest of them? Aside from the cost of the expedition, which would be considerable, the distance was great, the conditions to be met unknown, the possible danger from the animals themselves uncertain.

The answer to the query was made by Mr. Douglas Burden, a young man with sporting tastes, a real interest in natural history, and experience in collecting in tropical climates. As it turned out, the climate was the least of the troubles, for Mr. Burden records that it was all that could be desired, and had it not been for the ants, life would have been very pleasant. Mr. Burden organized and fitted out an expedition that should not merely obtain specimens of the dragon lizard, but also information in regard to their haunts and habits. So he took with him Mr. Dunn, a

[1] *Dragon Lizards of Komodo:* An Expedition to the Lost World of the Dutch East Indies. By W. Douglas Burden. G. P. Putnam's Sons, New York. 1927.

well-known herpetologist, and a "movie" photographer, while Mrs. Burden, who was a member of the party, was a skilled still-photograhper.

How Mr. Burden went to Komodo by way of China, how the party shot, trapped, photographed, and studied the dragon lizards, together with the many interesting events that took place not only during the stay on Komodo, but in going and coming, are well told in his story of an expedition to a lost world.

If the reader wishes to see some of the results of the expedition, he will find in the Hall of Reptile Life in the American Museum a group portraying the lizards in their most picturesque surroundings, while near by a reel of motion pictures shows them as Mr. and Mrs. Burden saw them in real life. And as one watches these big beasts stalking through the grass, or tearing out the bait, he may well imagine that the geological clock has turned backward a few million years and that he is having a glimpse of a lost world. And, besides this, Mr. Burden sent home two living specimens that for a time graced the New York Zoological Park.

If anyone thinks that this expedition was merely a sportsman's trip to secure a few trophies, he will find that, due to Mr. Burden's interest in science, Mr. Dunn, who brought the living animals to New York, has prepared a chapter in this interesting volume in which is summarized what we know to date of the giant lizards of Komodo.—F. A. L.

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SINCE the last issue of NATURAL HISTORY, the following persons have been elected members of the American Museum, making the total membership 10,146

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A NEW POLICY FOR "NATURAL HISTORY"

Beginning with the MARCH-APRIL NUMBER

Natural History will no longer present a series of special numbers, but will, instead, publish issues containing articles covering a wide diversity of subject matter. The March-April number itself will contain articles on the following subjects:

"The Natives of Australia's 'West'" by Clark Wissler.
"Rivers That Flow Underground" by Chester A. Reeds.
"How Central Asia Travels" by William J. Morden.
"Symmetry in Nature" by Herbert P. Whitlock.
"Some Mistakes of Scientists" by Frederic A. Lucas.
"A Thousand Miles of Coral Reef" by Roy Waldo Miner.
"Little 'Beasts of Prey' of the Insect World" by Frank E. Lutz.
"The Caves of Mt. Elgon" by James L. Clark.
"Native Dwellings of North America" by Pliny E. Goddard.

The cover design of the magazine will be a painting of the head of an Australian native by Arthur A. Jansson, and the entire magazine will be more lavishly illustrated than heretofore.